Developing A Public School Maintenance System

For the

Quincy Department of Public Works

An Interactive Qualifying Project Report submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the Degree of Bachelor of Science

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April 28, 2005

Acknowledgements

The team would like to thank everyone who helped in the completion of this project.

The employees of the Quincy Public School Maintenance Department

The employees of the Quincy Department of Public Works

The custodial staff of the Quincy Public Schools

Also, a special thank you to our project liaison;

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The Boston Project Center Director

Prof. Fabio Carrera, Worcester Polytechnic Institute

Our project advisors

Prof. Hossein Hakim, Worcester Polytechnic Institute

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Abstract

The goal of our project was to assist the Department of Public Works in Quincy, Massachusetts in creating a more efficient approach for the maintenance of the public schools. General and detailed evaluations were developed to assess the conditions of the nineteen schools, a bus depot, and a stadium. Each building received a general evaluation, and detailed evaluations were performed on Parker and Wollaston Elementary Schools. A database and ranking system were created to organize the data and identify the more serious maintenance issues. Overall, the result was an efficient, structured, electronic maintenance system.

Executive Summary

The Quincy Department of Public Works (DPW) is responsible for the maintenance of all the public schools in Quincy, Massachusetts. Their current maintenance system did not include a systematic approach to preventative maintenance. With a limited financial budget for maintenance, the Department of Public Works needed a system that would allow it to move away from performing emergency based maintenance and employ a more efficient preventative maintenance process. Therefore, the ultimate objective of this project was to develop a system that would help the DPW assess and maintain the conditions of the public schools more efficiently.

The first step in creating such a system was to research what requirements and guidelines were involved in school building maintenance. The Massachusetts State Building Code provided a good basis from which to determine what types of maintenance issues were relevant to the project, and helped in the design of a general assessment. The Massachusetts Department of Education website provided more specific physical requirements of school buildings, which helped to define exactly what was required of the assessment portion of the system. The last research component of the project involved reading through several hundred files related to school building maintenance and regulations within Quincy. This provided the team with a good idea of how the DPW performed maintenance on the schools, and what types of maintenance issues were more serious than others.

Once the research had been completed, work began on modifying the condition assessment forms from last year's project involving the rest of the public buildings in Quincy. Their assessment consisted of a general evaluation, followed by a detailed, room by room evaluation of a building. After some work with the sponsor, the general evaluation underwent several revisions. An equipment inventory of the capital equipment in each school was added to the form, along with a general assessment of the major components of the schools (i.e. roof, exterior, gymnasium, cafeteria, etc.). The detailed evaluation underwent some changes as well. It was converted to a quantitative assessment format to reduce user bias, and the forms were modified for each type of room found in a school building by adding the school specific requirements. As a whole, the detailed evaluation is made up of a checklist for each subsystem of a room. These subsystems include electrical, HVAC, plumbing, interior envelope, telecommunications, and emergency systems. Each form for each room type contains different criteria in these subsystems.

Once the forms had been finalized, the team collected data at nineteen schools, a bus depot, and a stadium in Quincy. The general evaluation was performed at all of the buildings to complete an inventory of all the capital equipment in the schools. The detailed evaluation, however, was a much more time consuming process and was only performed at two elementary schools, Parker and Wollaston. The result of these evaluations was a large amount of raw data that had no practical use for the DPW. The next step was to find out a way to store it efficiently.

Because of the large amount of data that had to be organized, it was determined that an electronic database was the best path to pursue. Last year's project had established a decent database structure in Microsoft Access that was able to handle the input from the detailed evaluations. However, it lacked in user friendliness, and had to be modified to handle all of the updates that had been made to the general and detailed evaluations. A new general evaluation form was added to the database that allowed for the general comments about each building to be added to the database. An equipment inventory form was also created to organize all of the equipment and allow the user to sort the data by equipment type, age, school, etc. A new maintenance record form was then created which allowed the DPW to enter in maintenance orders that are completed, and maintain an up to date, accessible record. The detailed evaluation form was broken down into each subsystem, the new criteria were added, and the labels were changed to make the form more readable and user friendly. The result was a much more efficient and complete database structure that held substantially more useful data than before.

The process of converting the data to a useful format was also taken care of by the database. The detailed evaluation is designed to provide a ranking of each room, floor, and overall building on a scale of 1-5, 5 being the best. This ranking is performed by the database using queries, a tool available in the software. Each individual item on the detailed evaluation form has its own variable within the database, and each subsystem has its own weight based on the room type. These variables are combined to form equations in the queries for each subsystem. Once each subsystem has been rated, an overall room rating is created by running a separate query that includes all of the subsystem ratings. These room ratings are then presented in a printable report for each individual building. These ratings then show exactly what areas of a building have maintenance issues that need to be addressed, or which areas are in good condition. The whole rating system can be refined to provide the desired ratings for the severity of the maintenance issues at hand by changing the weights and formulae in the queries.

Overall, the database provides an efficient way to maintain maintenance records, and create up-to-date reports on any type of equipment or system within the buildings. The best way to make use of this system is to continually update the information. The DPW ultimately has the say in how this is done, but it is recommended that the janitorial staff perform the general evaluations on a regular basis, and that interns perform some form of the detailed evaluation on all of the schools. However, this is only a portion of what is required for an effective preventative maintenance process. In order to establish a complete program, an extensive cost analysis should be done that provides a detailed breakdown of the material and labor costs associated with each type of maintenance issue. By tying in this cost analysis with the database, accurate cost estimates can also be produced along with each room rating, allowing the DPW to efficiently determine the best path to budgeting and fixing any problems. In conclusion, the DPW should take advantage of this tool and begin to adapt their system towards a more structured maintenance process.

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1 Introduction

One of the biggest assets to any developed community is the network of public buildings available to its citizens. As this network ages, it is important that the older buildings be maintained for the public, and it is generally accepted that this responsibility falls in the hands of the local authorities. The proper maintenance of these buildings requires that the local authorities have the budget and motivation to do so. Successful maintenance programs also require well organized records that allow the authorities to determine what projects need to be completed, and the costs for these projects. Many states around the country ranked poorly in public maintenance in a study done by the University of Richmond. Some of the lowest ranked states included Montana, Alabama, and New Hampshire. Montana's need for public maintenance topped $180 million and lacked a statewide strategic information plan. Only two states, Utah and Virginia, received A rankings[1]. In the long run, a well run public building maintenance program will extend the life of these resources and save public money.

Narrowing down the scope of public buildings, public school buildings are of particular interest. A survey estimated that it would take about 127 billion dollars to bring every school in the United States up to federal standards[2]. This shows the need for more cost effective maintenance programs throughout the country at the local level. Cities throughout the country have slowly started to address this issue. In Buffalo, NY, a consulting firm was hired to examine the maintenance needs of the schools and explore other options of maintenance procedure, including privatization.[3] It is not only older buildings that have maintenance issues that need to be addressed, but new school buildings that may quickly fall into disrepair. In Washington D.C., an 18 month old school building had paint peeling off the walls, water stains on the ceilings, and algae growing in the ducts and pipes[4]. This may have been a construction problem, but steps were not taken quickly enough to improve the conditions before they reached their current point. Quincy,

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[1] Anez, Bob. (2005, January 31). Report Raps State for Poor Planning by Government. The Associated Press and Local Wire. News.

[2] Eschbacher, Karen. (2004, September 16). School work under way; Quincy buildings get facelift. The Patriot Ledger. News.

[3] Simon, Peter. (2004, October 30). Consulting Firm will Evaluate Maintenance. The Buffalo News.

[4] Fernandez, Manny. (2004, August 21). Jancy Pledges Extra Effort to Fix Schools; New D.C. Superintendent Describes Disrepair as Totally Unacceptable. News.

Massachusetts is currently addressing the issue of public school maintenance and is searching for a more cost effective method.

The Quincy Department of Public Works (DPW) maintains all of the 19 public schools in Quincy. In 2004, the town spent 1.5 million in maintenance costs on its 12 elementary schools, 5 middle schools, and 2 high schools[5]. To address the problem of maintenance and improvements, the city bonded $1 million for capital improvements in June 2004[6]. Quincy is also in the planning stages of a multi-million dollar project to build a new high school and completely renovate an existing school[7]. It is important that the DPW is able to efficiently manage maintenance issues, and a variety of capital-related projects.

The Quincy DPW has recognized a need to improve their information collection process on all of its public school buildings. The process to improve the availability of up-to-date information began last year with the public building maintenance project done by a group of students from WPI for their Interdisciplinary Qualifying Project[8], and provided a good base from which to begin addressing the issue of public school maintenance. Currently, the lack of up-to-date data on the buildings does not allow the DPW to perform preventative maintenance and replace or repair things in the schools as they wear and age. Instead, emergency maintenance is scheduled when mechanical systems or physical components break. The Department of Public Works' current system of collecting data on the public school buildings does not allow for the proper planning needed to make efficient use of the available maintenance resources. The current process of addressing maintenance problems as they arise will impede the Department's ability to produce long term maintenance plans and budget proposals.

The main objective of this project was to help the Quincy Department of Public Works develop a plan for long term public school building maintenance by organizing information detailing the conditions of the existing buildings. By visiting each of the schools, the team gathered essential information needed to plan ahead for future maintenance. The team then created a ranking system used to evaluate various aspects of the schools that may require maintenance, and by doing so helped the Quincy DPW create a

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[5] Eschbacher, Karen. (2004, September 16). School work under way; Quincy buildings get facelift. The Patriot Ledger. News.
[6] Wynn, Brion. Personal interview. 21 March 2005.
[7] Eschbacher, Karen.
[8] **Blizard, Ian,** Edward O'Connell, and Erik Schmidtberg. *A Public Building Maintenance System for Quincy, Massachusetts.* WPI. 20 April 2004.

more efficient maintenance plan. The team analyzed the types of building maintenance issues that were present, the need for a more organized maintenance process, and addressed the future needs of the school buildings.

2 Background

The ultimate goal of this project was to help develop a long term maintenance planning process for the Quincy Department of Public Works. In order to do this, one must understand exactly what goes into the proper maintenance of buildings, and what standards the existing buildings must meet. The following sections outline general building maintenance and cover more specific areas such as school building maintenance based on learning objectives and safety and maintenance management.

2.1 General Building Maintenance

The maintenance of buildings consists of many tasks that need to be performed in order for a building to be correctly maintained. A building consists of many systems that need continued upholding. The systems can be categorized into a few divisions; the following list shows the divisions of a building that need to be maintained.

1. Structural systems
2. Roofing systems
3. Exterior envelope including windows, caulking, stucco, paint
4. Air conditioning, heating, and ventilation systems (HVAC)
5. Elevators and escalators
6. Electrical switchgear, lighting, power distribution, emergency generators
7. Plumbing systems
8. Fire sprinkler systems and pumps
9. General housekeeping and janitorial

Understanding the different components is crucial in making an evaluation of a building's status. It is important that each of these components are properly maintained over time to prolong their life and the life of the building.

2.2 Exterior Maintenance

The exterior of a building must be able to withstand the natural elements to provide safety and comfort for the people within the building. The exterior includes the outer structure, doors, windows, roof, and drainage system. All these components work together to protect the building from damage due to water, wind, extreme heat, and extreme cold.

The outer structure of the building is its first form of defense. This may be constructed of many different materials, such as brick, stone, concrete, wood, or vinyl siding. None of these materials are immune to deterioration and wear, therefore the upkeep is important to the life of the building.

The roof of a building is either flat or pitched. There are advantages and disadvantages to both designs but the aspect of protection from the elements is of importance in both cases. A roof needs to be fixed if it leaks and if there are any load bearing or structural damages. With the roof setting upon the top of the building, any leaks or structural damage can lead to more problems within the building.

The drainage system of the roof is very important to alleviate water damage to the building and its foundation. They system must be maintained and cleaned to ensure that it will flow smoothly and not cause backup upon the roof which may lead to leaks and mold. Also, the point of drainage is important so that the water flows away from the building to not cause water damage to any part of the buildings or ground.

The doors and windows give the people inside access to the outside and vice versa. This causes concerns of weather resistance, energy loss, and security. Windows can be of single or double pain, reflective, or heat-absorbing. The type of window will help with energy gain and loss, and the type of security. A window that does not open will be of less security concern then one that does. Proper locking devices must be in place. Proper closure of doors is also important to ensure the least amount of energy loss and security. Having up to date doors and windows will help save money in the long run with the advantage of less energy loss.

2.3 Interior Maintenance

The interior of a building goes through the most human interaction and is very susceptible to more physical damage on top of normal wear and tear. The interior should be aesthetically pleasing but also perform its function. The interior includes the floors, walls, and ceilings. The choice of material for each of these aspects is important in trying to save money in the long term, as some areas will have higher traffic volume and human interaction then others.

The utilities of a building are most important to the people who utilize the building day to day. These utilities include the heating, ventilation, air-conditioning, electrical, telecommunications, data, plumbing, and fire protection. These systems must be maintained so that an emergency situation doesn't arise and cause problems for the people that utilize the building.

Knowing by what method a building is being heated is very important. A building may use gas, oil, or electricity for their method of supplying heat. Forced hot air, baseboards, or radiators may be used to heat different sections of the building. No matter what method is used, it is important to perform routine maintenance to ensure that building will not have to be shut down due to a malfunction in heating on a cold day. Also, routine maintenance and cleaning will provide better efficiency of the boilers or furnaces.

Air quality in a building is very important. The proper installation of fans and ducts help circulate the air and bring in fresh air. This helps distribute the heating and cooling of the building and will alleviate stagnant air. The environment within the building must be healthy for its occupants each day.

The electrical, telecommunications, and data are needed each day for the people of the building to function. Proper wiring is vital to the life of the system and preventing the problems and dangers of blow fuses and electrical fires. Much of the wiring is behind the walls and hard to access except at lighting fixtures, outlets, phone jacks, and Ethernet ports. All lighting fixtures, outlets, phone jacks, and Ethernet ports should be known to find nearest point of access in case of a problem.

The plumbing of a building also must be in order to allow people to function day to day. Proper route of flow is important so that all liquids can flow freely and problems of gravity are avoided. It is also important to make sure that if one pipe goes wrong; all other things don't have to be shut down in all cases. Knowing the locations of water output and input are important for closest point of access in case of a problem.

The fire protection system must be maintained to save the people inside a building and the building itself. The sprinklers, extinguishers, and alarms should be up to inspection and a map of all locations must be made. All exits and extinguishers must be clearly marked and easily accessible. If the building has any fire escapes they should be checked for any structural damage.

Being aware of a building's components and their workings is vital to the life of the building. Each component must be in working order to provide an overall building of good working order. The smallest problem left unfixed will soon multiply and lead to more problems. Proper maintenance of each component will help plan for the future.

2.4 Building Maintenance Codes

When examining the condition of a building, it is important to break up the components of the building so that they can be evaluated more thoroughly. The three basic components are the outer surfaces, including the roof and exterior walls, the interior surfaces, which are ceilings and interior walls, and lastly the utilities of the building, such as electrical and heat, ventilation, and air conditioning systems. Each of these components must be up to date with the Massachusetts Building Code by law.

The first basic component of a public building is the exterior surface. The roof is obviously essential to the life of the building. Massachusetts State Building Code states that all roofs must be made with proper roof coverings that are securely attached to the frame of the building, and the roof coverings must be made to resist wind, rain, and fire. Roof coverings are defined as being any cover to the roof for weather resistance, fire resistance, or for appearance[9]. To inspect whether a roof is up to code, a thorough inspection is needed to tell if the roof leaks when exposed to rain. The underside of the roof also needs to be inspected for any damage that could have been caused by water leaking into the building.

The next subcomponent of the exterior of a building is the exterior wall covering. Much of the standards that apply to the roof also apply to the exterior walls as well. The wall coverings must obviously be made to withstand wind, rain, and fire. The inside space of the exterior walls must be fitted with a substance that will prevent vapor from leaking into the building through condensation[10]. All joints and edges of the exterior walls that will be exposed to the weather elements must be caulked with an approved durable waterproofing

[9] "The Massachusetts State Building Code (MSBC)." 254
[10] "MSBC." 243

material[11]. Massachusetts State Building Code also has requirements for minimum thickness of weather coverings of exterior walls, depending on what kind of material the wall is made of. Because the focus is on public schools, it will be assumed that most of the exterior walls will be made of brick and concrete masonry surfaces. The minimum thickness for weather covering on brick is 2 inches[12].

Moving inside the building, the next component is the interior wall surfaces, including windows and doors. Massachusetts has various requirements for the interior of buildings such as ventilation and lighting. Just like the exterior surface of the walls, the interior walls must also be able to stop the spread of vapor into the building. All habitable rooms must be properly ventilated. The process of ventilation can be artificial through the use of an HVAC system, or naturally by the use of doors and windows. If natural ventilation is chosen, the opening used to ventilate must be at least 4% of the floor area that is to be ventilated. Also, if a room does not have an opening to the outside and it uses an adjoining room for ventilation, then the opening to the adjoining room must be at least 8% of the floor space of the room being ventilated. Lighting specifications for Massachusetts state that artificial lighting must at least provide enough lighting to equal natural light that occurs outdoors[13].

The Massachusetts Department of Education (D.O.E.) has even more specific interior building requirements for its schools. The D.O.E. states that the dining hall of all schools must be large enough to accommodate enough tables and chairs for students to eat and not be crowded. The dining area must also be well lighted, well ventilated, and clean. It also required of the schools that their classrooms be large enough to accommodate all of the students being taught, based on their size and number[14].

Included in the Massachusetts D.O.E. requirements for public schools are a number of general provisions for the interior of the school. The school must make sure that the floors, ceilings, and walls of the rooms used by students are clean, free of cracks, and free of hazardous or protruding objects. All steam and hot water pipes must be surrounded by a permanent screen or barrier that will keep students from coming into contact with them. In

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[11] Ibid., 246
[12] Ibid., 244
[13] Ibid., 205
[14] "Education Laws and Regulations."

addition to these safety requirements, all Massachusetts public schools must have at least thirty-five feet of activity space per student[15].

Massachusetts Building Code has many requirements for interior walls made to save energy. According to code, a continuous air barrier must be made throughout the interior of the building in order to prevent the leakage of air into or out of conditioned areas. All joints in the walls and ceiling must be sealed, air-tight and durable. All doors and windows, including doors to stairwells and elevator doors, must be properly installed so as to not allow a great deal of air leakage to occur. Doors that separate the inside from the outside of the school and are intended to be entrances must have a vestibule. The doors on both sides of the vestibule must have self-closing devices, and it must not be possible for a person passing through the vestibule to have both doors open at once. To make sure that this is possible, the minimum distance between these doors is seven feet[16]. The Massachusetts D.O.E. also requires that at least one entrance to the school not have steps and be wide enough for a wheel chair, in accordance with the Rehabilitation Act of 1973[17].

The last components of a public building that must be maintained and evaluated are the utilities of the building. One of the main utilities is the electrical system, which must be installed correctly so that wiring is not exposed and does not create a fire hazard. State code requires that installation, repair, and maintenance of electrical systems must be done in accordance with the Massachusetts Electrical Code. The electrical system must also be approved by the Board of Fire Prevention Regulations of the Commonwealth of Massachusetts[18]. Another main utility of public buildings is the HVAC system, including heating, pumping, process piping, and refrigeration systems. It is required of all public buildings in Massachusetts that the outdoor air intake of the HVAC systems be a certain distance away from objects that may contaminate the air. For example, the outdoor air intake must be at least 25 feet away from any driveways or any area where automobiles may be running to prevent the intake from taking in the exhaust fumes. HVAC systems must also be installed and maintained by contractors licensed by the Commonwealth of Massachusetts[19]. The requirements of the plumbing systems in public buildings are very similar to those of the electrical and heating systems. Plumbing systems must be installed and maintained by

15 "Education Laws and Regulations."
16 "MSBC." p. 248
17 "Education Laws and Regulations."
18 "MSBC." 415
19 Ibid., 417.

properly licensed contractors, and they must meet the requirements set forth by the Massachusetts Fuel Gas Code[20].

When evaluating the plumbing system, it is important to note the quality of faucets, sinks, and bathrooms to make sure that the system is being maintained and is not creating any sanitary problems. In addition, the Massachusetts D.O.E. has its own requirements for the general plumbing of pubic school buildings. All schools must have hot and cold running water in sinks. They must also have at least one toilet and sink for every 14 students that attend the school. Toilets and sinks must be installed that are accessible for handicapped students[21].

One of the most important features of the interior of the building is its fire protection system. The Massachusetts State Building Code requires that all buildings having two or more stories or having an occupant load of 300 or more have a standpipe fire protection system. This fire protection system must be able to automatically discharge an appropriate fire-suppressing agent in the event of a fire, and the agent must be at a suitable quantity and pressure to allow it to perform the function intended[22]. The school authorities are responsible for the maintenance of this fire protection system to ensure the safety of the students and faculty of the school. If the fire protection system needs repair or is found to be unserviceable, the local fire department must be called immediately. Schools are also required to have proper signs throughout the building to identify fire protection equipment, equipment rooms, and equipment locations. These signs must be durable, permanently installed, properly visible, and must be approved by the local fire department[23]. Fire extinguishers are another important aspect of fire protection in schools. Fire extinguishers must be made by an approved agency, placed in convenient locations, and be readily available to all occupants in the building. There must be fire extinguishers in all laboratory rooms, or any rooms where there is use of combustible materials[24].

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[20] Ibid., 421
[21] "Education Laws and Regulations."
[22] "MSBC." 163
[23] Ibid., 147
[24] Ibid., p. 177

2.4.1 School Building Maintenance

Public building maintenance in itself is a difficult responsibility that any city must deal with, but the maintenance of public schools is an even more complicated task. Problems with public school buildings must be fixed at times that will not distract from the learning environment. If the city does not plan properly for the maintenance of a public school buildings, they may be faced with a situation where something in the building breaks and must be fixed immediately. If this situation occurs at a time when school is in session, the repair could become a disruption to the students and teachers of the school. Planning is needed to prevent emergency repairs and to allow time for repair during time periods when school is not in session, such as during the summer or winter vacations. This planning requires knowledge of the schools and its building systems so that it is known when maintenance is required.

2.4.2 Importance of Safety

The safety of the occupants of a building is the most important part of building maintenance. This is even more evident with school buildings that are filled on a daily basis with students and faculty. A new guide for school maintenance created by the U.S. Department of Education states that there are four major safety issues that must be addressed when it comes to school maintenance. These issues are air quality, asbestos, water management, and waste management[25]. It is essential that each of these aspects of public school building maintenance is taken care of to ensure the safety of everyone inside the buildings.

Indoor air quality is especially important in public schools, and regular maintenance of air vents and ventilation systems is required to keep the air quality at a safe level. The U.S. Environmental Protection Agency or EPA offers an air quality checklist that can be used to check the overall safety of air quality in a school building. Included in this checklist are requirements for heating, ventilation, and air conditioning equipment (HVAC) that must be properly maintained and used in the correct places so that the air quality is as safe as possible[26]. The U.S. Department of Education recommends that all HVAC and ventilation

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[25] U.S. Department of Education. "Planning Guide" 44
[26] Environmental Protection Agency. "IAQ Tools"

equipment be balanced every five years to make sure that the air is being ventilated properly[27].

The condition of water in public schools is also of significant importance when planning for building maintenance. The United States EPA has set standards for the maximum allowable amount of contaminants that are present in the water of schools. To meet these standards, schools must make sure that lead-lined water coolers are properly maintained or removed to ensure that their water does not contain dangerous amounts of lead. Schools also have to make sure that all of their water storage tanks and equipment are up to date and properly maintained so that the water is not contaminated. Schools are also unique because there are many times when their water use is at a peak level, and so the water storage facilities must be able to handle peak demand[28].

2.4.3 Department of Education Requirements for Public School Maintenance

The state of Massachusetts has certain laws for the maintenance of public schools that Quincy must abide by. In 1998, a new law was put into effect in Massachusetts that required all public schools to allocate more of their budget each year toward maintenance. This law states that each district's annual spending on school building maintenance must equal or surpass 50% of the amount of money that is budgeted for ordinary or extraordinary maintenance that year[29]. Extraordinary maintenance is defined as being maintenance that lengthens the life of a component of the school building or the actual building itself. To satisfy this requirement, the schools of Quincy must spend 50% of their school maintenance budget on any non-salary expenses that contribute toward the operation of the school. If any of the schools own employees fix or work on maintaining the school building, then these expenses are not covered under the law. If the schools fail to meet these spending requirements effective in September of 1999, they will lose their eligibility for funding from the state[30].

With this law in mind, it is important to know how much money the city of Quincy has available to maintain their public schools. In the first year that this law was effective,

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[27] U.S. Department of Education. "Planning Guide" 45
[28] Ibid., 50
[29] Massachusetts Department of Education. "Advisory Memorandum on New Spending Requirements for School Building Maintenance." 8
[30] "Advisory Memorandum." 9

Quincy's school maintenance budget was $2,691,921 for ordinary maintenance and $1,756,206 for extraordinary maintenance[31]. Adding these two together and dividing the answer in half gives Quincy a spending requirement of about $2,224,064 for the year 1999. This amount of money may seem high just to maintain schools, but not when it is taken into consideration that this money must be divided among 19 public schools. With Quincy having such a large number of schools, it is important that the school maintenance budget be used in the most cost-effective manner possible. A more cost-effective system will require more knowledge about each individual school. This knowledge can then be organized and used to plan ahead so that maintenance to the schools does not become an emergency task that needs to be done immediately.

2.5 Maintenance Management

The planning and scheduling of building maintenance is an integral part to a successful maintenance management plan. In order to set an effective plan for maintenance, an efficient means of distinguishing tasks that need to be performed must be established. Planning and scheduling of building maintenance allows for more efficient procedures and decreases the costs associated with maintenance.

The planning process for building maintenance first starts with identifying and documenting the work that needs to be performed[32]. Accurate information early in the process will ultimately make the maintenance procedures easier. A structured process needs to be developed to plan maintenance work. Plans need to be prioritized according to conditions to allow for accurate future planning. A planning method has to be established that accounts for budgets and estimating costs. Information pertinent to building maintenance can be accurately used to help in estimation of costs. A preventative and predictive maintenance plan is also a major source of plan able work. Preventative maintenance will decrease the need for emergency maintenance and implement more accurate estimation on costs[33]. Good planning maintenance will eventually permit for more accurate scheduling.

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[31] Ibid., 16
[32] Mather, Daryl. Fundamentals of Maintenance Management. 16 Feb. 2005 <http://maintenanceworld.com>.
[33] Planning and Scheduling Machine. Comp. Michael V. Brown. News standard institute. 10 Feb. 2005 <http://newsstandard.com>.

Scheduling work makes it possible to prioritize maintenance work based on need. In order to find the most effective means of completing a job, accurate scheduling must be made. Also scheduling allows time to find the most appropriate and efficient procedure for completion. Scheduling can be accomplished by using calendars and backlogs that establish goals and dates[34]. In building maintenance, scheduling is highly relevant because many tasks must be performed periodically. Maintenance schedules should also allow for time to deal with unforeseen emergencies that may exist. Scheduling is a changing process due to unanticipated events that occur, continuous revisions must be made to ensure proper scheduling of building maintenance[35].

2.6 Demographics of Quincy Public Schools

Quincy has 19 public schools, including 11 elementary schools, five middle schools, two high schools, and a center for technical education. Quincy prides itself on having small class sizes, and many of the elementary schools have less than 20 students for every teacher. The middle schools and high schools all meet the requirement set by the Quincy School Committee of less than 25 students for every teacher per classroom[36]. This requirement is met with 2,968 active students between the two high schools, 1985 students in the five middle schools, and 3,106 students in the 11 elementary schools. Elementary schools in Quincy include grades one through five, middle schools have grades 6-8, and high schools grades 9-12. [37]

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[34] Idem
[35] Mather, Daryl. Fundamentals of Maintenance Management. 16 Feb. 2005 <http://maintenanceworld.com>.
[36] Quincy Public Schools. "About Our District."
[37] Quincy Public Schools. "District Profile."

3 Methodology

The ultimate objective of this project was to help the Quincy Department of Public Works develop a plan for short and long term public school building maintenance by organizing information about the conditions of the existing buildings. The team analyzed the types of building maintenance issues that were present, the need for a more organized maintenance process, and addressed the future needs of the school buildings. There were three objectives central to the success of this project.

1. Assessment of current conditions of the schools
2. Development of a maintenance planning tool
3. Demonstration of the effectiveness and re-usability of the tool

The results of last year's project on Public Building Maintenance provided the basis for this year's project on the maintenance of Public School Buildings[38]. Utilizing the database structure created by last year's project on public building maintenance allowed the current team to address more specific issues and refine the system. The following sections describe the plan of action used to complete the above objectives. See the Results and Analysis section for details on each particular step taken during the period of the project.

3.1 Current School Conditions

The first step in assessing the current school conditions was to create a tool capable of performing such a function. In this case, a data collection system created by last year's team provided an excellent foundation from which to build. The system consisted of a general evaluation field form and a series of detailed evaluation field forms. The field forms required some modification to include more specific requirements of schools (i.e. gymnasiums, pools, libraries, etc).

[38] Blizard, Ian, Edward O'Connell, and Erik Schmidtberg. *A Public Building Maintenance System for Quincy, Massachusetts.* WPI. 20 April 2004.

3.1.1 Identifying School-Specific Requirements

In order to modify the forms created by last year's team, the requirements specific to school buildings were identified, and the team determined which requirements were of importance to the buildings' functionality and safety. It was also important for all of the information useful to the DPW to be identified. By researching the specific learning objectives of schools set forth by the Massachusetts D.O.E., the actual physical requirements of the building were determined. Once this list was created, walkthroughs of several school buildings with the sponsor took place, highlighting the areas of importance to him.

Once the new school-specific forms were created, the system was tested. This was completed by emulating what last year's team did; individually assessed a particular building and compared the results. In this case, several rooms from the DPW building were evaluated and compared among the group and to last year's results. Some values were found to have large variances among the individual assessments, so the input parameters of those values were further clarified. The test run also helped discover any potential issues that were left out of the system. This revolving process of refining the system and re-assessing the requirements was present throughout the entire data collection process, and the forms were continually updated throughout the first half of the project.

3.1.2 Collecting the Information

The general evaluation form was used to perform a broad evaluation of nineteen schools to determine their overall condition, and create an inventory of existing capital equipment. Figure 1 shows the locations of the schools. All nineteen general evaluations were completed first. This helped improve our data collection skills and refine the forms. The detailed evaluation consisted of a room by room evaluation of a school, with a specific form for each room type. Because the scope of the project was quite big, it was impossible to perform a detailed evaluation and analyze data on each individual school in Quincy before the seven week period ended. After the general evaluations were completed, the sponsor helped determine that Parker and Wollaston Elementary Schools were the best candidates for a detailed evaluation. To assure that this portion of the project would be completed, a time schedule of access to each building was created ahead of time. The room evaluations were split up among the four group members as well, in an attempt to complete each building in a reasonable amount of time.

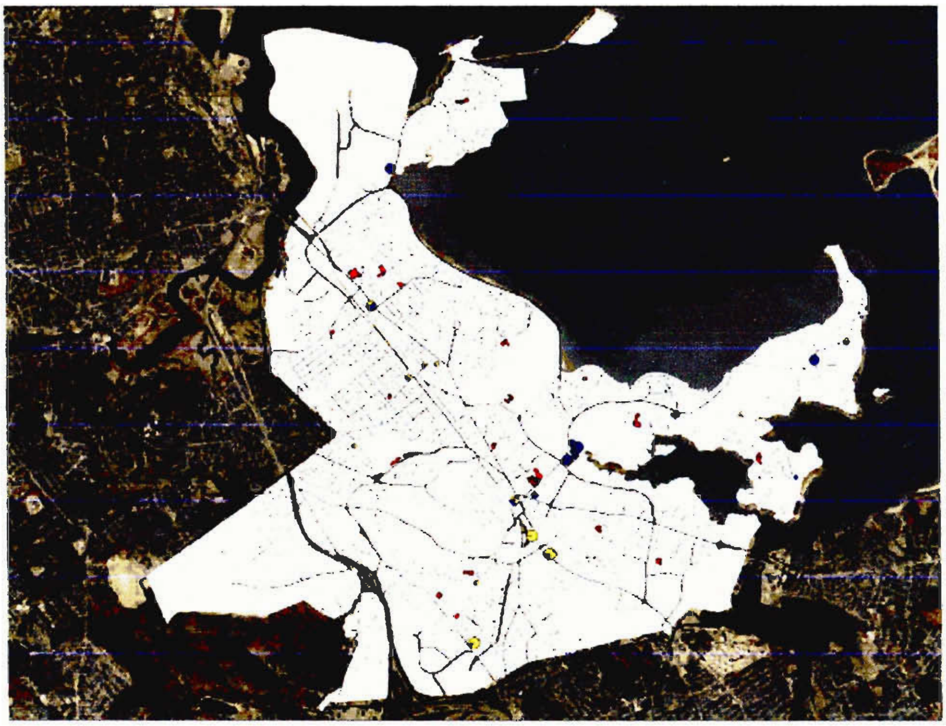

Figure 1: Location of Quincy Public Schools

3.2 Modifying the Existing Database

Once the data was collected, the next step was to organize it electronically. The database created by last year's team was a two tiered system, which followed the layout of the general and detailed evaluation forms. The first layer was a general overview of each school (i.e. location, age, type of school, condition of major building components, etc.). This first layer only developed an overall condition of each building, and required several modifications dealing with form design and data fields. The second layer, however, was critical to the in-depth analysis of each individual building, and required extensive modification to the forms, ranking formulae, and layout of the database in order to make it more user-friendly and efficient.

Creating a more accessible dataset required the entry of each field form into the electronic database. A coding structure based on building name, grade level, and room number was used to help organize each entry in the tables. The blueprints of Parker and

Wollaston Elementary Schools were also digitized and linked into the database, due to the fact that they were both selected to receive a detailed evaluation. This allowed for a visual display of each school's analysis to be created, and portrayed the location of the more serious maintenance issues, as well as what the issues were. Details on the coding structure and the visual representation can be found in the Results and Analysis section.

3.3 Determining Re-usability

The first key component to the re-usability of the process is the revamped database. A large amount of information is stored in it, and that requires an efficient, easy to use interface. The creation of a well structured database that is easy for anyone to use (i.e. guides them through data entry, requesting data, and modifying forms) allows the DPW to accurately and easily record and find maintenance information. The second key to the re-usability of the process is the continual updating of the database. By maintaining accurate information, accurate rankings and reports can be created. An up-to-date system will ensure the avoidance of unnecessary emergency maintenance repairs, and allow the DPW to act on maintenance issues in a timelier manner. The system will demonstrate its re-usability as the DPW begins to update the information and create detailed reports on buildings or systems within the buildings on a regular basis.

4 Results and Analysis

The results of this year's project can be separated into two areas. The first area includes the actual data that was collected and the means by which the data was collected, the field forms. The second area includes the database structure that was created to organize and analyze the collected data.

4.1 Data Collection

The team collected a large amount of data throughout the several weeks of the project. The main tools used in the data collection process were created by last year's project team. These tools included a general evaluation and a detailed evaluation, and both forms were modified to fit the needs of the school buildings in Quincy. A general evaluation was performed on nineteen schools, a bus depot, and Veterans stadium. This process allowed the forms to be field tested and changed as required, until they satisfied the needs of the sponsor. In fact, several of the schools required second visits to obtain more information as the field forms changed. Once this stage of the data collection was finished, the result was an up to date set of information detailing the equipment and condition of the buildings, and an efficient, easy to use form for further evaluations.

The second part of the data collection process involved a detailed evaluation, which was used for each room within a particular building. In this case, Wollaston and Parker Elementary Schools were chosen as the two buildings to perform this detailed evaluation. It was found that the time required to complete this evaluation was much less than originally thought. Both schools were completed in two afternoons of work (about twenty man hours of work), although Parker took somewhat longer to complete due to its larger size. The result of this stage of the evaluations was a large amount of raw data that had to be entered into the database to provide any useful information.

4.1.1 General Evaluation Form

The general evaluation form consists of several sections and is designed to identify major maintenance issues and create an inventory of equipment within the building (see Appendix A for complete version of this form). The first section (Table 1) identifies any major problems on the exterior and roof of the building. The left side of the form lists each of the items that must be evaluated, and the right column allows space for any comments to be written. For some items, there are common options that can be circled, as seen in the roof type row. Because the form is open-ended, the user ultimately determines if there is a legitimate problem with any part of the building. Therefore the user must have some experience in determining between serious maintenance issues, and issues that are merely cosmetic.

Table 1: General Evaluation Form - Exterior and Roof Sections

GENERAL EVALUATION FORM	
Use: Elem/Middle/HS/Admin/Other	Inspection Date:
Building Name:	Inspector:
Square Footage:	
Exterior	**Write Comments Below:**
Windows	
Foundation	
Roof Flashing	
Parapet/ Masonry	
Other Comments	
Roof	
Type	Slate | Shingle | Gravel | Rubber
Leaks	Frequent | Random | Widespread | Localized
Drains	
Pooling Issues	
Other Comments	

The second section (Table 2) asks for an inventory of the capital equipment present in the building. Each type of equipment critical to the operation of the building and the well-being of its occupants is listed. These include boilers, burners, compressors, generators, water heaters, HVAC systems, return tanks, vacuum pumps, and PA systems. The form asks for the make, model, and serial numbers of each piece of equipment, as well as the year built and the condition the equipment is currently in. This portion of the evaluation is very straightforward, however, it does require to user to be able to identify the types of equipment in the building, and recognize when items are not in good condition.

The third section of the form covers the safety and emergency systems (Table 3). This section allows for a count of the fire extinguishers, the date they were last inspected, the sprinkler coverage, the types of fire alarms, and whether or not everything is in good working order. This also provides an inventory of the safety equipment in each building.

Table 2: General Evaluation Form - Equipment Inventory

Compressor	
Make	
Model	
Serial	
Year Built	
Comments	
Generator	
Make	
Model	
Serial	
Year Built	
Comments	

Table 3: General Evaluation Form - Safety

Safety	
Insulation Condition	
Fire Alarms	
Extinguishers	Last Inspected:
Sprinkler System	Full Coverage | Partial Coverage | No Coverage
Other Comments	

The last section of the general evaluation (Table 4) documents the specific components of a school building, including the library, gymnasium, cafeteria, auditorium, kitchen, security system, elevator, and A.D.A Compliance (American's with Disabilities Act).

As in the case of the exterior and roof section, it is up to the user to determine if any serious issues are present in any of these areas.

The general evaluation form takes anywhere from one to two hours to complete, depending on the size of the school and the condition it is in. The user must have a basic knowledge of building equipment, and be able to recognize the difference between serious and non-serious building maintenance issues. Overall, this form established an up-to-date inventory of all capital equipment in the school buildings, and recorded any major maintenance issues in the building.

Table 4: General Evaluation - School Specifics

School Specifics	
Library	
Security	
Elevator/ Lift	
ADA compliance	
P.C. Labs	
Auditorium	
Gymnasium	
Cafeteria	
Kitchen	Full | Reheat
Other Comments	

4.1.2 Detailed Evaluation Form

The detailed evaluation form consists not only of several sections, but is made up of several forms. Appendix A shows a full form listing each question. Each section deals with a specific building system including electrical, emergency, elevators, HVAC, plumbing, interior, and exterior, and combinations of different sections make up different forms for each type of room found in a school building. Each section contains questions or criteria used to evaluate that specific system in each room type. In summary, the criteria used to evaluate each room changes with each different type of room. The room types that have their own specific detailed form include office, classroom, utility room, bathroom, storage area, common area, kitchen, gymnasium, roof, and exterior. These room types are sufficient to cover an entire school building.

Table 5 shows the layout of the detailed form. The three columns on the left (#, Y, N) allow the user to record values or answer a yes/no question corresponding to the criteria to the right. Each question can be answered in this format, although the right-most column allows the user to write comments relating to any particular criteria. Also included in this figure is a portion of the electrical and telecommunications criteria. Each criterion in every system on the form has its own relative importance in the condition assessment of each room, which is explained in detail later on.

The major difference between this detailed evaluation and the general evaluation is that the detailed evaluation is a quantitative assessment and is not affected by user bias. Therefore, the user that performs a detailed evaluation does not need to understand building maintenance at the same level as a user performing a general evaluation.

4.1.3 Data Types

The collected data can be broken down into three different categories or groups. The general evaluation contains two different groups of data. The first type of data is the comments on the conditions of the school areas and components. Since these comments cannot be used to directly determine a condition of a particular room or building, they can mainly be used as a source of general information on a particular building. The second type is the nameplate data from the equipment inventory on the general form. This information can only be used for informational purposes as well, but the more structured data fields such as the year built and the equipment type allow the user to sort through the inventory based on their needs.

Table 5: Detailed Evaluation - Form Layout

			COMMON	
			Room Name:	
			Use: General Public Inspection Date:	
			Building Name: Inspector:	
			Public / Private:	
			Square Footage:	
			CONDITION ASSESSMENT	
#	***Yes***	***No***	***Criteria***	***Comments***
			Electrical/Telecommunication/Data	
			Outlets	
			How many 3-prong outlets are there?	
			How many 2-prong outlets are there?	
			How many surge protectors are there?	
			How many extension cords are being used?	
			How many outlets are being used?	
			Ethernet	
			How many ethernet ports are there?	
			How many ethernet ports are being used?	
			How many network hubs being used?	
			Phone	
			How many phone lines are there?	
			How many phone lines are being used?	
			How many splitters are being used?	

For example, if the user was interested in sorting equipment by type and age to determine if any components were becoming obsolete, it would be possible to do so. The third type of data collected is the numerical, and yes/no data taken from the detailed evaluations. Since these data are so basic, they can be used quite easily to perform an analysis of each room, floor, and building of their respective schools. This process of ranking the rooms is explained in the analysis section. Organizing this information on paper would have been quite a tedious and time consuming task; therefore an electronic database was used to make the process efficient.

4.2 Database

Although last year's project resulted in a basic database structure, there was still much room for improvement. The general evaluation, which had been modified extensively during this project, had not yet been built into the database, and the several new fields that dealt with school specific components and were added to the detailed evaluation had to be included in the database. The user-friendliness was also an issue, in that there was a large learning curve to overcome before being proficient at using the database. These problems were dealt with over the entirety of the seven week period, as learning the database software proved to be a challenge in itself.

4.2.1 Database Structure

The overall structure of the database is built to follow the format of the data collected by the field forms, and organize the information for the user. Figure 2 shows the basic concept behind the design of the database, and the process by which the data is analyzed is covered in the analysis section. The flow of the chart is downward, and as the data is processed through the database, the ultimate result is a detailed report on any particular room, floor, or building that exists in the database. The individual forms for the detailed evaluations, general evaluations, and equipment inventory have all been modified from last year's project or created this year.

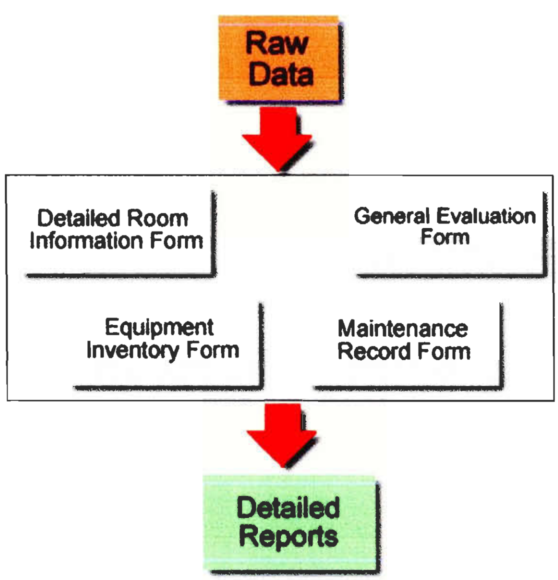

Figure 2: Database Overview

The detailed form is the largest form tied to the database. It contains every field from the detailed evaluation forms. Figure 3 shows a layout of just the electrical system on the form. The rest of the form is similar in layout, with checkboxes, pull down lists, and fields for all of the other systems. The major changes to this form involved making it more user-friendly and adding in the fields for additional requirements that had been added to the field forms.

The equipment inventory form was a brand new addition to the database. Because more emphasis than last year was placed on the general evaluation of the schools and the form was entirely re-created, it was necessary that a section of the database be designed to organize all of the general evaluation data. Figure 4 shows the newly designed equipment inventory form, which is part of the general evaluation. The layout allows the user to enter the nameplate data of each piece of equipment, as well as what school it belongs to. The tabbed boxes at the bottom of the form contain additional data unique to certain types of equipment listed at the top. This helps save a large amount of space on the form, and helps eliminate confusion that may arise from many unfilled fields.

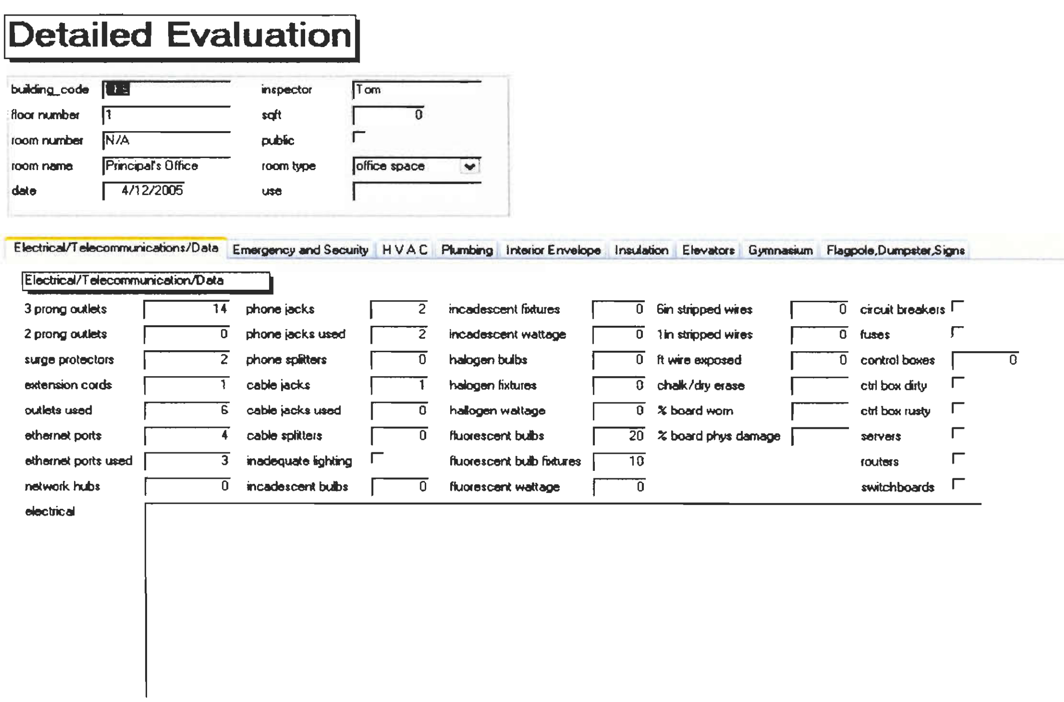

Figure 3: Detailed Database Form - Electrical System

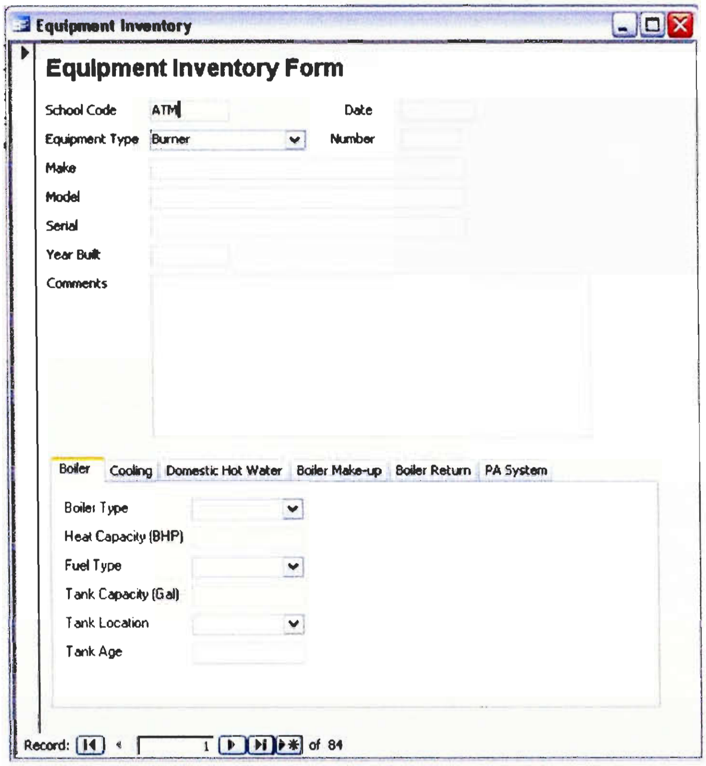

Figure 4: Equipment Inventory Form

The second form created this year was the general evaluation form. Unlike the equipment inventory form, the types of data being dealt with through this form were mostly user comments. Therefore, this portion of the general evaluation was kept separate from the equipment inventory form. Figure 5 shows the layout of the general evaluation form, and the multitudes of comment fields are visible. Because of the comment style data, this form could not be involved in the analysis process, but was kept as a source of updatable information on each school building that is included in the detailed reports of each building.

Another new addition to the database this year was the maintenance record form. This form is not based on any particular field form, but allows the user to input every maintenance issue that has been resolved. This allows for an organized record of costs, timelines, types of maintenance, and other comments to be built up over time. Ultimately, the user will be able to sort through these maintenance records by school, type, and cost, and be able to provide better estimates for future maintenance needs. This form can be seen in Figure 6.

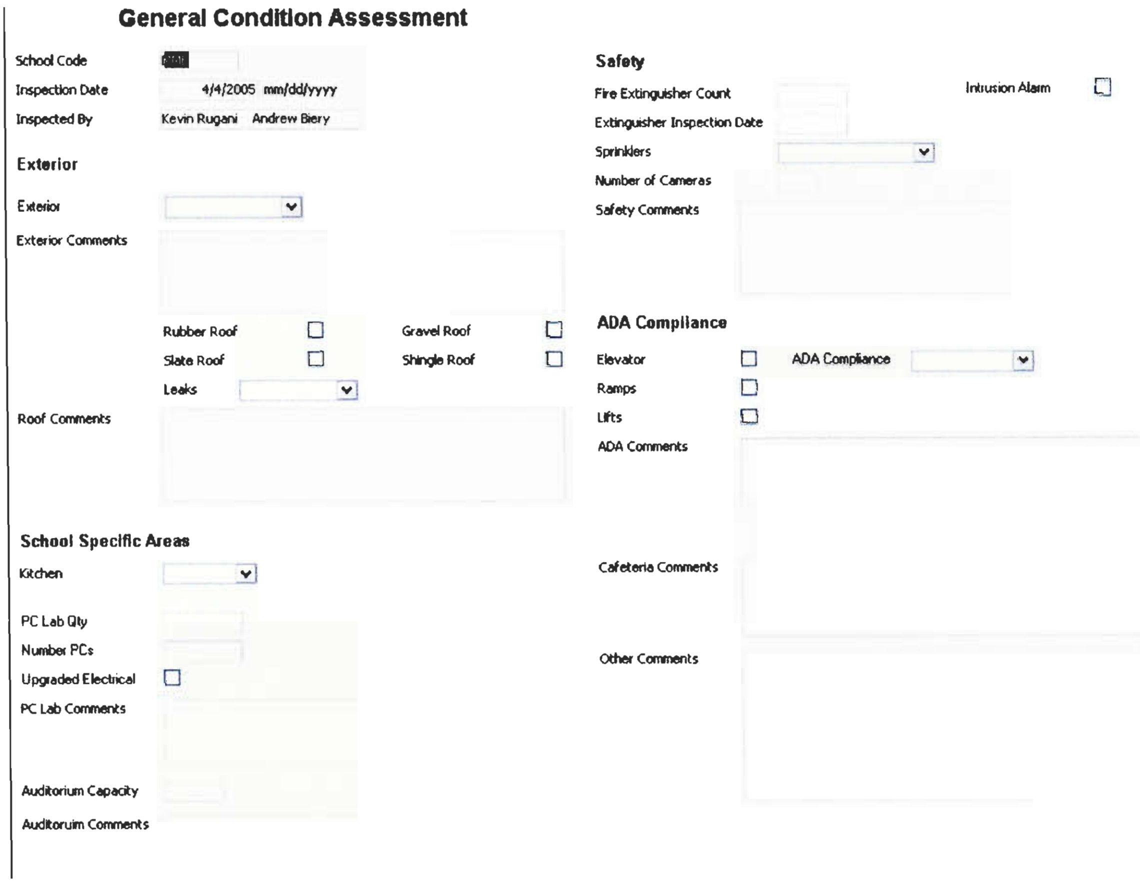

Figure 5: General Condition Assessment Form

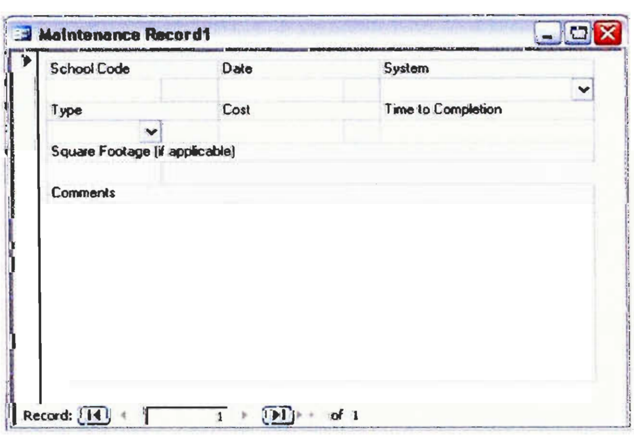

Figure 6: Maintenance Record Form

The "behind the scenes" portion of the database consists of the means by which the data is analyzed. Aside from the tables associated with each of the forms are tables that contain the room system weights, and tables that contain formatting information for the forms. The actual calculations that take place in the database are performed by queries, which are explained in detail in the section 4.3.1 of the report. Each component of the database is able to be modified and updated to the user's specifications. Overall, the user-friendly, efficient database that was desired at the beginning of the project was completed.

4.3 Database Internal Operation

Once all of the data on the Quincy public schools was collected, a system was created that presents the information in a more user-friendly form. The data from the general evaluations was put into a database so that it would be organized and easy to access if needed. The information from the detailed evaluations on Parker and Wollaston is complex and specific to each school building and room, and therefore it would be very time consuming for anybody to attempt to use the collected information in this form. To make the information more user-friendly, the data that was collected on each room during the detailed evaluations was first entered into a database that is separate from the general form database. Through the use of a series of formulas and weighting systems that are part of the database, this data is first turned into a ranking of each subsystem of each room, such as the electrical, plumbing, and HVAC systems, as well as the overall envelope of the room, which includes floors, walls, and ceilings. After each subsystem is ranked, an additional weighting system is used to rank the importance of each system in each individual room. Then all the ranks of each room on a floor are averaged so that an overall floor rank is obtained. Finally, the floor ranks are averaged and an overall building rank is obtained. More information on exactly how the formulas and ranking systems of the database work are included in the sections that follow.

4.3.1 Ranking System

The ranking system from last year's project team was the base design for our ranking system. Once all of the data is entered into the database and all of the formulas are run, an overall rating for each room could be obtained. Last year's group used a scale of 1-5 to rate each room, floor, and building which is summarized as follows:

1. Very poor
2. Poor
3. Satisfactory
4. Good
5. Excellent

In order to make it easy for anyone to look at the available 2-D and 3-D drawings in the database and immediately know the condition of each room, a color key was created to represent room conditions (see Figure 7). This color key corresponds to the number scale above. The following are the colors and the room conditions they correspond to:

1. Black
2. Red
3. Yellow
4. Orange
5. Blue

One of the major flaws we found in last year's database was the formula and the method used to rank the walls, ceilings, and floors of the rooms, which are all part of the envelope subsystem of a room. When attempting to rank an entire ceiling, it is difficult to judge how badly damaged the overall ceiling is and give it a rank.

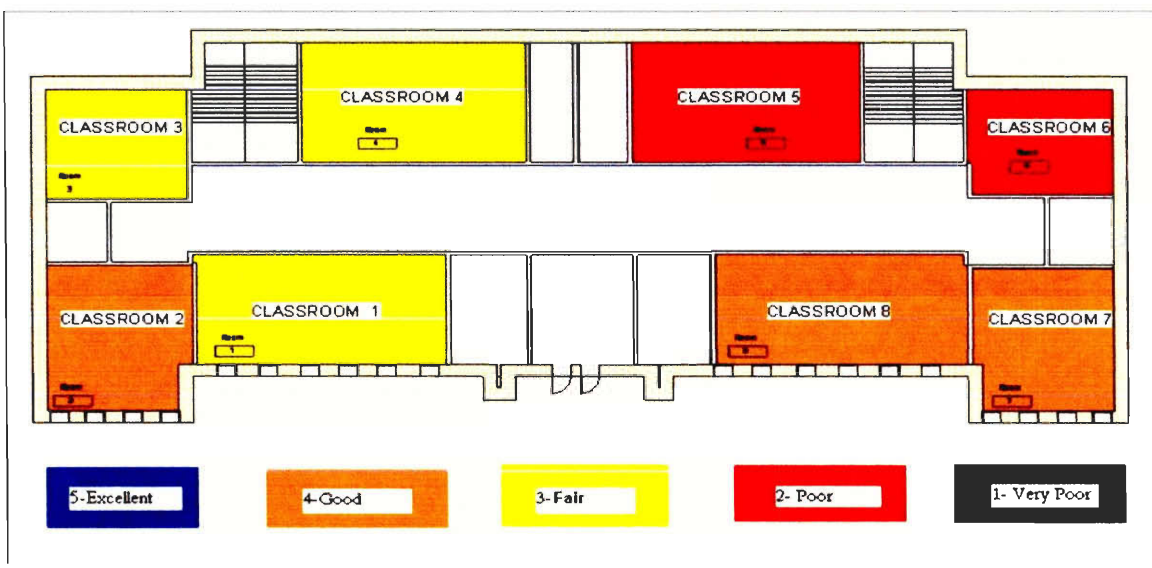

Figure 7: Color Coded Room Ratings

To make this process more quantitative, a new system was created. For example, an inspector is looking at a ceiling that has water damage in one small section of the room, but the ceiling is otherwise perfect. The inspector may choose to give this ceiling an overall rating of a 3 or "satisfactory" because of the small amount of water damage. However, ranking the ceiling in this way leaves out a lot of information. Anyone looking at the ranking of this ceiling would not know whether the entire ceiling was worn and thus warranted a ranking of a 3, or if most of the ceiling was mostly perfect and a small amount of damage was the reason for this ranking.

To fix this problem, a new system was created that explains why a wall, ceiling, or floor was rated the way it was. Instead of just one number that gives an overall rating, the new system uses three numbers to convey more information. Using the same example, the first step in using this new system is to identify the worst section of the ceiling, which is in this case a small amount of water damage. The first number that is recorded is the rank of this small section of water damage, which for example is a 2. The second number recorded is the percentage of the ceiling that this "worst" area covers. For this example it will be assumed that the water damage is a very small area, or about 5% of the overall ceiling. The third number recorded is the rank of the rest of the ceiling, which is in this case a 5.

After creating this system, a formula was needed that gives an overall rank to the wall, ceiling, or floor that is being evaluated. The formula needed to take all three numbers into account and also result in an appropriate number of 1-5 that accurately reflected the overall condition of the wall, ceiling, or floor. The resulting formula, which was created through a process of trial-and-error, included numerous iterations of different formulas. The following formula produced the best results based on the numerous combinations of different ratings that could arise, as we are trying to find an average value that represents the entire wall, ceiling, or floor. A complete reference for all formulas and rationale behind each formula can be found in Appendix F. Appendix E contains a variable chart that explains all the variables found in the formulas.

$$\textbf{Overall Ceiling Rating} = \frac{\text{(Worst part rank)(1- \% Worst part) + (Rank of rest of ceiling)}}{2}$$

(App. F - R15, R16, R17)

The numbers from the example in the previous paragraphs were:

Worst part rank: 2

% Worst part coverage of overall ceiling: 5%

Rating of rest of ceiling: 5

These numbers are plugged into the formula to get the overall ceiling rating on a scale of 1-5:

$$\text{Overall Ceiling Rating} = \frac{(2)(1-.05) + (5)}{2} = 3.45$$

The numbers result in an overall ceiling rating of 3.45.

There is one exception when this formula should not be used. This exception is when the ceiling, wall, or floor has a "worst part" that covers more than 33%. If the worst part covers a percentage of more than 33%, then the formula should not be used and the overall rank should be whatever the worst part rank is. If a third or more of the ceiling is the worst part rank, then the ceiling obviously needs attention and so the worst part rank should be used for the total ceiling rank. With damage that covers that much area, the chances are great that there is more than one factor contributing to this, such as a leak in the roof or plumbing if it is a water damage situation. These factors also contributed to the creation of formulas used to establish rankings. To show why this exception is needed, the following example will be used. Suppose that the following numbers were recorded after observing a ceiling:

Worst part rank: 3

% Worst part covers of overall ceiling: 50%

Rating of rest of ceiling: 4

These numbers in formula:

$$\text{Overall Ceiling Rating} = \frac{(3)(1-0.5) + 4}{2} = 2.75$$

The overall rating that results is 2.75, which is not accurate. Since half the ceiling is a rating of 3 and the rest is a rating of 4, then the overall rank should fall somewhere between these two numbers. However, if the worst part of the ceiling is a 3 and covers so much space, then the lower, more dramatic ranking should be used to make sure that the ceiling gets the proper attention needed in the future. Therefore, for this example the overall ceiling rating will result in a 3. An If-Then statement is built into the database for this formula so that this exception will automatically take effect.

Using this formula, one can get three separate ranks for the ceiling, floor, and walls of the room. The next step is to enter the ranks of all of the doors and windows of the room. The formulas created by last year's project group were used to obtain ranks for the doors and windows. Included in the detailed evaluation forms are questions about each door that ask what percentage of the door face is damaged, as well as the percentage of the door frame that is damaged. There are also questions that ask how many of the doors are inoperable, and also how many of the locks on the doors are inoperable. Similar questions are also used to evaluate the windows of the room. Almost every question in the detailed evaluation form equals a variable in a formula in the database. Each one of these variables is explained in detail in Appendix E. Each formula in the database is also explained in detail in Appendix F.

Rating the doors and windows in the database is more complicated than rating the floors, ceiling, and walls. The first formula used to rate the doors takes into account the number of doors that are inoperable. This formula gives a rank of 0-5 based on the number of doors that are broken. The more doors that are broken, the lower the rank will be. If all of the doors are in proper working condition, then the rank will be a 5. If all of the doors are broken, then the rank will be a 0. This formula in the database is called pct_door and is as follows:

Rank of doors based on how many are inoperable = 5-((% of doors that are inoperable)*5)
(App. F - Q1)

The next formula used to rate the doors takes into account the number of locks on the doors that are inoperable and is called pct_lock (App. E - Q1). This formula is very similar to the pct_door formula and also gives a rank of 0-5. This 0-5 ranking does not follow the 1-5 ranking system, but this is taken into account when calculating the total room rating, which will always result in a ranking of 1-5. This is the case with many of the formulas contained within the overall ranking formula.

Moving on, the next set of formulas splits the doors into different categories and gives them a rating based on the percentage of damage they have to their faces and frames.

There are separate rankings for the closet doors, interior doors, and exterior doors. The closet door formula, which is identical to the interior door formula, is shown here:

Ranking of closet doors based on percentage of doors that are damaged

(clo_rate) = (200-((% closet face damaged)+(% closet frame damaged)))/40 (App. F - Q2)

This formula also gives a rank of 0-5. Once again, if 100% of the closet door faces and frames are damaged, then the formula will result in a rank of 0. If 0% of the closet doors and frames are damaged, then the formula will result in a rank of 5. These results are obtained because of the 200 in the numerator and the 40 in the denominator, since 200/40=5. The number in the numerator is 200 because when both variables equal 100% then the numerator will equal 0, since 200-100-100=0.

The names of the closet door, interior door, and exterior door formulas in the database are clo_rate, int_rate, and ext_rate respectively (App. E - Q2). The exterior door formula is slightly different than the other door formulas because there is an additional question on whether or not the exterior doors have weather stripping. With this additional question added, the formula for the exterior doors is:

Ranking of exterior doors based on percentage of doors that are damaged and whether or not doors have weather stripping

(ext_rate) = (300-((% face damaged)+(% frame damaged)+(100-(% w/ weather stripping)))/60 (App. F -Q2)

This formula is very similar to the closet door and interior door formulas, except that a 300 is in the numerator and a 60 is in the denominator because 300/60 =5, which is the highest rating that can be achieved. The number in the numerator is 300 and not 200 because there is an extra variable in the equation. When all three variables equal 100, the numerator will result in a 0, since 300-100-100-100=0.

The next step is to put all of these rankings together to come up with an overall door rating. The final rating of the door or rate_door is given by the following formula, which includes the results of the previous formulas:

Overall door rating (rate_door) = ((([ext_rate]+[pct_door]+[pct_lock])*2)+[int_rate]+[clo_rate])/8 (App. F - R13)

This formula includes the rankings from every door variable and combines them to create an overall door ranking for the room. If every ranking is a 5, then the numerator will equal 40, and dividing this by the 8 in the denominator, an overall door ranking of 5 is obtained.

After the final door ranking is obtained, we then get the window rating from the following formula:

Overall window rating (rate_window) = (200-([ext_glass_dam]+[int_glass_dam]))/40

(App. F - R14)

The ext_glass_dam (App. E, Interior Envelope) is the percentage of the area of the exterior windows that is damaged, while the int_glass_dam is the area of the interior windows that is damaged. This window formula works exactly like the closet door (clo_rate) formula that was explained previously.

Now that separate rankings for the ceiling, floor, walls, windows, and doors have been obtained through the formulas shown here, an overall interior envelope ranking can be calculated with another formula. This formula uses a weighting system that places more emphasis on certain parts of the envelope and is shown here:

Overall interior envelope ranking
(rate_int_env) = ((16*[rate_ceil])+(32*[rate_door])+(8*[rate_floor])+(28*[rate_window])
+(16*[rate_wall]))/100

(App. F - U5)

The numbers before each rating in the numerator add up to 100 and show the particular weight that was given to this aspect of the room. The higher the number in front of each part of the room, the more important it is that this part of the room be maintained properly. The numerator is then divided by 100 to get a ranking from 0-5. If each rating in the numerator is a 5, then the numerator will come out to be 500. Dividing 500 by 100 results in a 5, which is the appropriate result for the overall interior envelope rating.

Doors were rated highest in this formula because they are used so frequently and must be in working order so that the room can be accessed. Windows are also rated high because if they are broken, heat in the room will be lost and it will be hard to maintain a comfortable temperature in the room. Floors were rated lowest because emergency maintenance is not required if the floor is worn or has cracks in it.

This is just one example of how all of the questions on our forms about the envelope are taken into account in the database and then used to create an overall ranking. This process is also used on the other aspects of the room as well, including the electrical, emergency, HVAC, and plumbing systems. Once rankings for all of these room systems have been obtained, another ranking system is used to get an overall rank for the entire room. Obviously, certain subsystems are more important in some rooms than in others. For example, the electric subsystem of a PC room is much more important than the electricity on the roof, and so the electric subsystem is given much more weight when evaluating the PC room. Just like the weighting system for the subsystems of each room (Appendix B), this weighting system also adds up to 100 when all of the weights are put together. This room weighting system was also originally created by last year's project group and then added to and improved upon this year by our group. Brion Wynn gave suggestions as to what numbers could be changed to more accurately reflect the importance of the room subsystems.

There are separate formulas for each type of system in the room. Here is the formula for this weighting system for the interior envelope of the room:

Weight of interior envelope in room

(weight_int_env) = IIf([rm_type]="lavatory",20,IIf([rm_type]="exterior",30,IIf([rm_type]="general public",30,IIf([rm_type]="officespace",30,IIf([rm_type]="utility",6,IIf([rm_type]="roof",75,IIf([rm _type]="auditorium",19,IIf([rm_type]="storage",28,IIf([rm_type]="gymnasium",35,IIf([rm_type]=" classroom",30,IIf([rm_type]="PCRoom",9,IIf([rm_type]="CafeteriaKitchen",15,15))))))))))))

(App. F - W4)

This formula uses many If-Then statements shown by the "IIf". The formula identifies the room type [rm_type] that was chosen for the room and then based on this room type, assigns the room a certain rank for the interior envelope. The numbers directly after each type of room show this rank, based on the relative importance of maintaining the envelope in that room. The higher the number, the more important it is that the envelope be properly maintained in that type of room. For example, there is a 75 directly after "roof" in the formula. The envelope for the roof was given a high ranking of 75 out of 100 because it is extremely important that the envelope of the roof be maintained. If there are holes or cracks in the envelope of the roof, then there will be major problems with leaks into the building. Therefore it is extremely important that any problems with the envelope of the roof are fixed as quickly as possible. The other room systems like electrical, emergency, HVAC, and plumbing were deemed less important when maintaining the roof and so they were given lower numbers. Shown below are the weights given to the roof. The numbers in the row add up to 100. The rest of this table is included in Appendix B.

Room Type	Electric	Emergency	HVAC	Plumbing	Envelope
Roof	10	5	0	10	75

Since it was sometimes unclear which rooms fell under which room categories, a detailed explanation of each room was created. It was also sometimes unclear which equipment in a room was included in which subsystem, and so a detailed explanation of each subsystem was created. These detailed explanations can be found in Appendix B.

4.3.2 Sample Calculation of Interior Rating

Ceiling:
Worst part rank: 3
% Worst part covers: 10%
Rank of rest of ceiling: 5
Overall ceiling rating = ((3)(1-.1))+5)/2 = 3.85

Floor:
Worst part rank: 2
% Worst part covers: 15%
Rank of rest of floor: 4
Overall floor rating = ((2)(1-.15))+4)/2 = 2.85

Wall:
Worst part rank: 3
% Worst part covers: 10%
Rank of rest of wall: 4
Overall floor rating = ((3)(1-.1))+4)/2 = 3.35

Doors:
Doors: 4   2 Interior 1 Exterior 1 Closet   % Inoperable: 25%
Locks: 4   % Inoperable 25%

Rank of Inoperable Doors: 5 –(.25*5)= 3.75
Rank of Inoperable Locks: 5 – (.25*5) = 3.75

% interior face damaged: 10% % interior frame damaged: 0%
% closet face damaged: 10% % closet frame damaged: 5%

Interior door rate: (200-(10+0))/40= 4.75
Closet door rate: (200-(10+5))/40= 4.63

% exterior face damaged: 10%
% exterior frame damaged: 0%
% w/weather stripping: 100%

Exterior door rate: (300-(10+0+(100-100))/60 = 4.83

Overall Door Rating: (((4.83+3.75 +3.75)*2)+4.75+4.63)/8 = 4.25

Windows:

Windows: 20 15 Exterior 5 Interior
% Exterior Damaged: 13% % Interior Damaged: 20%

Overall Window Rating: (200-(13+20))/40 = 4.18

Overall Interior Envelope:

Overall interior envelope ranking:
(rate_int_env) =((16*[rate_ceil])+(32*[rate_door])+(8*[rate_floor])
+(28*[rate_window])+(16*[rate_wall]))/100

((16*3.85)+(32*4.25)+(8*2.85)+(28*4.18)+(16*3.35))/100 = 3.91

With this more advanced and user friendly database, the DPW will now be in a better position to make complete evaluations of all schools. The database is very flexible, as a user with knowledge of Microsoft Access can make changes to equations or add equations by modifying or adding queries where needed. Also, creating new reports will allow for multiple groups of information to be compiled from the data entered. The ultimate goal of the database is to allow the DPW to make maintenance decisions in advance and save money. A brief user manual on simply inputting data from the field forms can be found in Appendix D.

5 Recommendations and Conclusions

The database created is a helpful tool that will contribute toward the creation of a preventative maintenance program. However, further steps need to be taken in order to use this tool in an effective manner. After all of the rooms in the schools have been ranked, the Quincy DPW can begin to make decisions on what parts of the schools they want to improve. The ranks of the rooms that the database creates will help them a great deal to identify what areas of each building need to be addressed, but further details need to be explored in order to make sure that the maintenance budget is being used in the most efficient manner possible. In addition to the information that the database provides on the condition of the schools, more details need to be taken into consideration such as the time required to properly evaluate all the schools, and the amount of money required in order to repair different parts of the school buildings.

If our plan is to be put into action, an estimate of the amount of man-hours needed to completely evaluate each school is needed. Estimating the amount of time will help the Quincy DPW to plan ahead for how much time needs to be put aside in order to evaluate each school building and update the database.

Our group was able to fully evaluate Wollaston Elementary School using both the in-depth and general field forms in about five hours. Multiplying this by the four, the number of people in the group, one gets 20 man-hours. Since Wollaston is 34, 576 square feet, we can use its size and compare it to other school sizes to estimate how long it will take to do the other schools. To estimate the amount of time it would take to do other schools of different sizes, the following simple formula was used:

(Size of school in square feet/34,576)* 20

A table that shows the time estimation for each school is included in Appendix C. This table shows that fully evaluating every school in Quincy would require a great deal of time. In order to avoid spending a great deal of money on employees to evaluate the school buildings, summer interns could be used by the Quincy DPW. If summer interns are not practical, then the custodial staff at each school could be used to evaluate the schools. Both of these options would cut down on the amount of valuable time that essential employees need to address other school maintenance issues.

In order for the database to be useful, it will need to be updated on a regular basis. Every time work is done on any part of any school, the date, price, and type of maintenance should be documented on the general field forms and added to the database. Adding this information to the database will make it readily available to anyone at the Quincy DPW so that it can be used to predict what parts of each building will need maintenance, and what parts of each building have been repaired recently. Also, each school should be fully evaluated once a year by either summer interns or the custodial staff so that the in-depth database can be updated. Updating the in-depth database will provide up-to-date information on the condition of each room in each school, and also the overall condition of each school.

A full cost analysis of every type of school building maintenance also needs to be performed. Obviously some parts of the schools cost more to repair or maintain than others. This must be kept in mind when planning ahead for maintenance. If one part of a school building is extremely costly to fix, then obviously it is very important to maintain this part of the school. If the parts of the school that are costly to repair are properly maintained, then they will not need to be repaired as often and money will be saved. For this reason, certain types of maintenance should be given priority over others.

After data has been collected on all of the schools and a proper cost analysis has been performed, the Quincy DPW can then make appropriate decisions on where to perform proper maintenance. They can look at the overall condition of each of the schools, compare the results, and decide which schools are most in need of maintenance. After deciding on which schools will need to be worked on, they can also look at the newly organized maintenance records and find out what parts of each school were recently worked on. This will allow the DPW to plan ahead for public school building maintenance and avoid emergency repair costs, which will lower overall maintenance costs.

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Appendix A: Field Forms

General Evaluation Field Form

GENERAL EVALUATION FORM	
Use: Elem/Middle/HS/Admin/Other	Inspection Date:
Building Name:	Inspector:
Square Footage:	
Exterior	**Write Comments Below:**
Windows	
Foundation	
Roof Flashing	
Parapet/ Masonry	
Other Comments	
Roof	
Type	Slate | Shingle | Gravel | Rubber
Leaks	Frequent | Random | Widespread | Localized
Drains	
Pooling Issues	
Other Comments	
Equipment	
Boiler	Qty:
Make	
Model	
Serial	
Year Built	
Comments	
Burner	Qty:
Make	
Model	

Serial	
Year Built	
Heat Capacity	
Fuel Type	
Comments	
Compressor	
Make	
Model	
Serial	
Year Built	
Comments	
Generator	
Make	
Model	
Serial	
Year Built	
Comments	
Water Heater	
Make	
Model	
Serial	
Year Built	
Comments	
HVAC System	
Make	
Model	
Serial	
Year Built	
Comments	
Return Tank	
Make	
Model	
Serial	
Year Built	

Comments	
Vaccuum Pump	
Make	
Model	
Serial	
Year Built	
Comments	
PA System	
Make	
Model	
Serial	
Year Built	
Comments	
Safety	
Insulation Condition	
Fire Alarms	
Extinguishers	Last Inspected:
Sprinkler System	Full Coverage | Partial Coverage | No Coverage
Other Comments	
School Specifics	
Library	
Security	
Elcvator/ Lift	
ADA compliance	
P.C. Labs	

Auditorium	
Gymnasium	
Cafeteria	
Kitchen	Full | Reheat
Other Comments	

Detailed Evaluation Field Form

COMMON	
Room Name:	
Use: General Public	Inspection Date:
Building Name:	Inspector:
Public / Private:	
Square Footage:	

CONDITION ASSESSMENT				
#	***Yes***	***No***	***Criteria***	***Comments***
			Electrical/Telecommunication/Data	
			Outlets	
			How many 3-prong outlets are there?	
			How many 2-prong outlets are there?	
			How many surge protectors are there?	
			How many extension cords are being used?	
			How many outlets are being used?	
			Ethernet	
			How many ethernet ports are there?	
			How many ethernet ports are being used?	
			How many network hubs being used?	
			Phone	
			How many phone lines are there?	
			How many phone lines are being used?	
			How many splitters are being used?	
			Cable	
			How many cable connections are there?	
			How many cable connections are being used?	
			How many splitters are being used?	
			Lights	
			Is there inadequate lighting in the room?	
			Incandescent	
			How many incandescent bulbs are there?	
			How many incandescent fixtures are there?	
			Total wattage	
			Halogen	
			How many halogen bulbs are there?	
			How many halogen fixtures are there?	
			Total wattage	
			Fluorescent	
			How many fluorescent bulbs are there?	
			How many fluorescent fixtures are there?	
			Total wattage	
			Wiring	
			How many wires have been stripped more than 6 inches?	
			How many wires have been stripped more than 1 inch?	
			How many feet of wiring is exposed?	
			Emergency and Security	
			Basic Equipment	

			How many fire alarm switches are there?	
			How many fire alarm sirens are there?	
			How many smoke detectors are there?	
			How many motion sensors there?	
			How many surveillance cameras are there?	
			How many exit signs are there?	
			How many fire extinguishers are there?	
			Back-up Equipment	
			How many lights are there?	
			Sprinklers	
			How many sprinklers are there?	
			Is there an inadequate number of sprinklers?	
			HVAC	
			Ventilation	
			How many vents are there?	
			What percentage of total vent area is blocked?	
			What is the area of ventilation?	
			Mold present?	
			Heating and Cooling Units	
			How many space heaters are there?	
			How many A/C units are there?	
			How many radiators are there?	
			How many baseboard heaters are there?	
			Mold present?	
			Thermostats	
			How many thermostats are there?	
			What is the room temperature?	
			Does the room temperature not match the thermostat temperature?	
			Plumbing	
			Is there any leakage?	
			How many drinking fountains are there?	
			How many water fountains are there?	
			How many toilets are there?	
			How many showers are there?	
			How many faucets are there?	
			How many drains are there?	
			Mold present?	
			Elevators	
			How many floors does the elevator service?	
			Has the elevator been serviced appropriately?	
			Has the elevator machine been serviced appropriately?	
			How many elevators are connected to the room?	
			Interior Envelope	
			Doors	
			How many exterior doors are there?	
			What percentage of the exterior door face is damaged?	
			What percentage of the exterior frames are damaged?	
			How many exterior doors have weather stripping?	

			How many interior doors are there?	
			What percentage of the interior door face is damaged?	
			What percentage of the interior frames are damaged?	
			How many closet doors are there?	
			What percentage of the closet door faces are damaged?	
			What percentage of the closet frames are damaged?	
			How many doors have locks?	
			How many locks are inoperable?	
			How many doors are inoperable?	
			Windows	
			How many panes of interior glass are there?	
			How many panes of exterior glass are there?	
			How many of the exterior windows multi-pane?	
			What percentage of the interior window panes are broken or cracked?	
			what percentage of the exterior window panes are broken or cracked?	
			Mold present?	
			Floor	
			Worst part of floor rating 1(worst)-5(best)	
			What percentage of the floor does the worst part cover?	
			Damage Type: Worn, Water, Physical	
			Rating of the rest of the floor?	
			Mold present?	
			Ceiling	
			Worst part of ceiling rating 1(worst)-5(best)	
			What percentage of the ceiling does the worst part cover?	
			Damage type: Worn, Water, Physical	
			Rating of the rest of the ceiling?	
			Mold present?	
			Walls	
			Worst part of wall rating 1(worst)-5(best)	
			What percentage of the wall does the worst part cover?	
			Damage Type: Worn, Water, Physical	
			Rating of the rest of the wall?	
			Mold present?	
			Insulation	
			Type of insulation?	
			Worst part of insulation rating 1(worst)-5(best)	
			What percentage of the insulation does the worst part cover?	
			Damage Type: Worn, Water, Physical	
			Rating of the rest of the insulation?	
			Mold present?	

Appendix B: Sub-System Weights for Different Rooms

Table 6: Table of Room Weights

Room Type	Electric	Security/ Emergency	HVAC	Plumbing	Envelope
Lavatory	5	20	20	50	5
Exterior of Building	5	20	0	5	70
General Public	15	25	30	5	25
Office Space	25	20	25	5	25
Roof	10	10	0	10	70
Storage	15	30	15	10	30
Utility	30	20	10	30	10
Auditorium	25	25	35	0	15
Gymnasium	5	30	30	5	30
Classroom	25	25	30	5	20
PC Room	40	15	30	0	15
Cafeteria/Kitchen	20	25	25	20	10
Library	20	20	30	0	30
Multipurpose Rooms	15	25	25	10	25

Description of Room Types and Categories

Room Types:

Lavatory: Any restroom that has only toilets and sinks, with no showers.

Exterior: Any part of the building that is exposed to the outside, not including the roof. Exterior windows are included in this room type.

General Public: All hallways, lobbies, stairwells and areas that are not part of a particular room.

Office Space: Any offices such as those used by secretaries and the principal. This room type does not include conference rooms, which are included under classrooms.

Roof: The roof of the school building.

Storage: Any room that is used specifically for storage. If a room is being used for storage but was not intended for this purpose, then it is NOT included under this room type.

Utility: Any room that is used to house utilities for the building, such as the boiler room.

Auditorium: Any room that has a stage and is used for the sole purpose of large gatherings for meetings or performances. If a room is used for both the gymnasium and the auditorium, then it is not included under this room type and is instead categorized as a multipurpose room.

Gymnasium: Any room that is used for gym class. If a room is used as both the gymnasium and the cafeteria, then it must be categorized under both room types.

Classroom: All rooms used as classrooms. Also included under this room type are conference rooms, art rooms, and libraries.

PC Room: Any room where PC's are used. If a room has many computers but is also used as the library, it is NOT considered a PC room.

Cafeteria/Kitchen: Any room that prepares food and is used for eating.

Library: Any room that is used solely as the library. If the library room is also used as the auditorium then it is not considered the library and is instead categorized as a multipurpose room.

Multipurpose Room: Any room that is used for more than one purpose, such as when a single room is used as the gymnasium and cafeteria, or when the library is also used as an auditorium.

Categories:

Electric: Any part of the room that is powered by electricity. Included in this category are lights, outlets, and intercoms. Also included in this category is the equipment in the boiler rooms, including the boilers, compressors, and generators. In the kitchen, stoves, refrigerators, and freezers are also included under the electric category.

Emergency: Fire alarms, fire extinguishers, sprinklers, exit signs.

HVAC: Any equipment that has to do with the heating, venting, and air conditioning of the room.

Plumbing: Any part of the room that has to do with drainage or piping, such as toilets, sinks, and drains. HVAC piping is not included in this category.

Envelope: Walls, floor, and ceiling. Also for the roof this includes the actual roof structure and roof material.

Appendix C: Time Estimates for Detailed Evaluations

Table 7: Evaluation Time Estimates

School	Size (sq. ft.)	Estimated Time (man-hours)
Wollaston	34,576	20
Atherton Hough	46,549	26.9
Beechwood Knoll	35,820	20.7
Bernazzani	32,558	18.8
Clifford Marshall	unknown	unknown
Della Chiesa	30,180	17.5
Lincoln-Hancock	98,164	56.8
Merrymount	43,750	25.3
Montclair	47,489	27.5
Parker	48,202	27.9
Snug Harbor	62,851	36.4
Squantum	43,975	25.4
Atlantic	92,343	53.4
Broad Meadows	93,760	54.2
Central	72,354	41.9
Point Webster	89,300	51.7
Sterling	73,880	42.7
C.T.E.	195,326	113
Quincy H.S.	255,493	148
North Quincy H.S.	305,000	176
G.O.A.L.S.	4,142	2.4
Veteran's Stadium	6,000	3.5
Bus Depot	1,800	1

Appendix D: Using the Database

All of the formulas and weighting systems described in this report may make using the in-depth database sound like a very difficult task, but it is actually not as hard as it seems. Before using the database, general and detailed evaluation forms need to be completed. These field forms can be found in Appendix A. After the forms are filled out, the data can be entered into the Access Database and the calculations can be performed and reports printed.

To begin, the user must open the Access database, "Building_Database", and choose "Forms" under "Objects" on the left side of the window (See Figure 8).

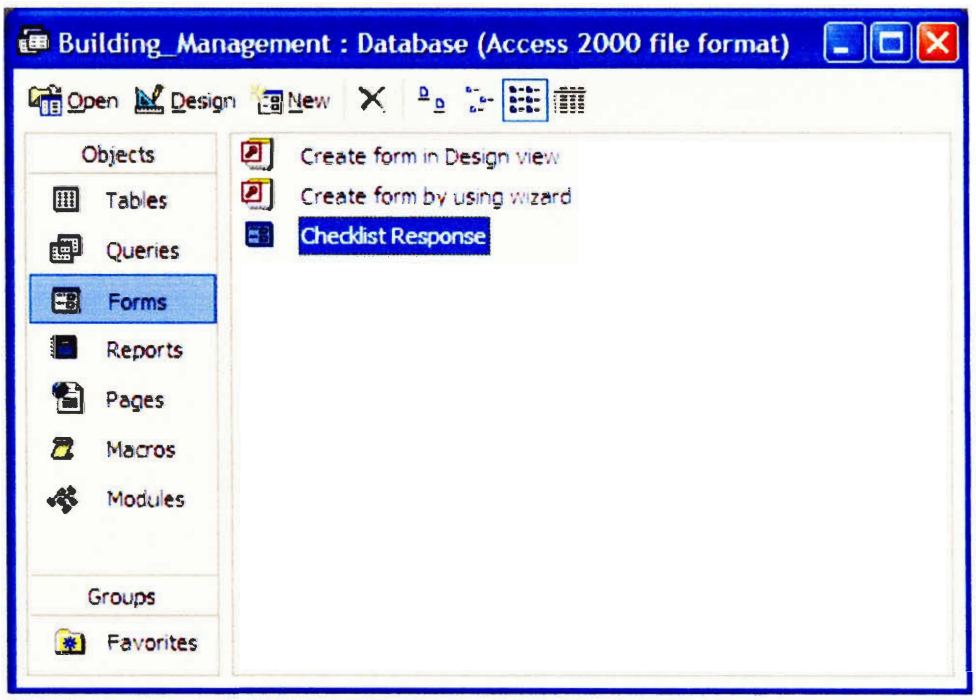

Figure 8: Main Database Window - Forms

The user must then click "Checklist Response" and the Detailed Evaluation form will pop up (Figure 9). If there is data already entered in the fields on the forms, such as seen below, then the button "New Record" can be clicked at the top of the screen to make a totally blank form pop up. After the blank form pops up, data from the paper form can be entered into the electronic form.

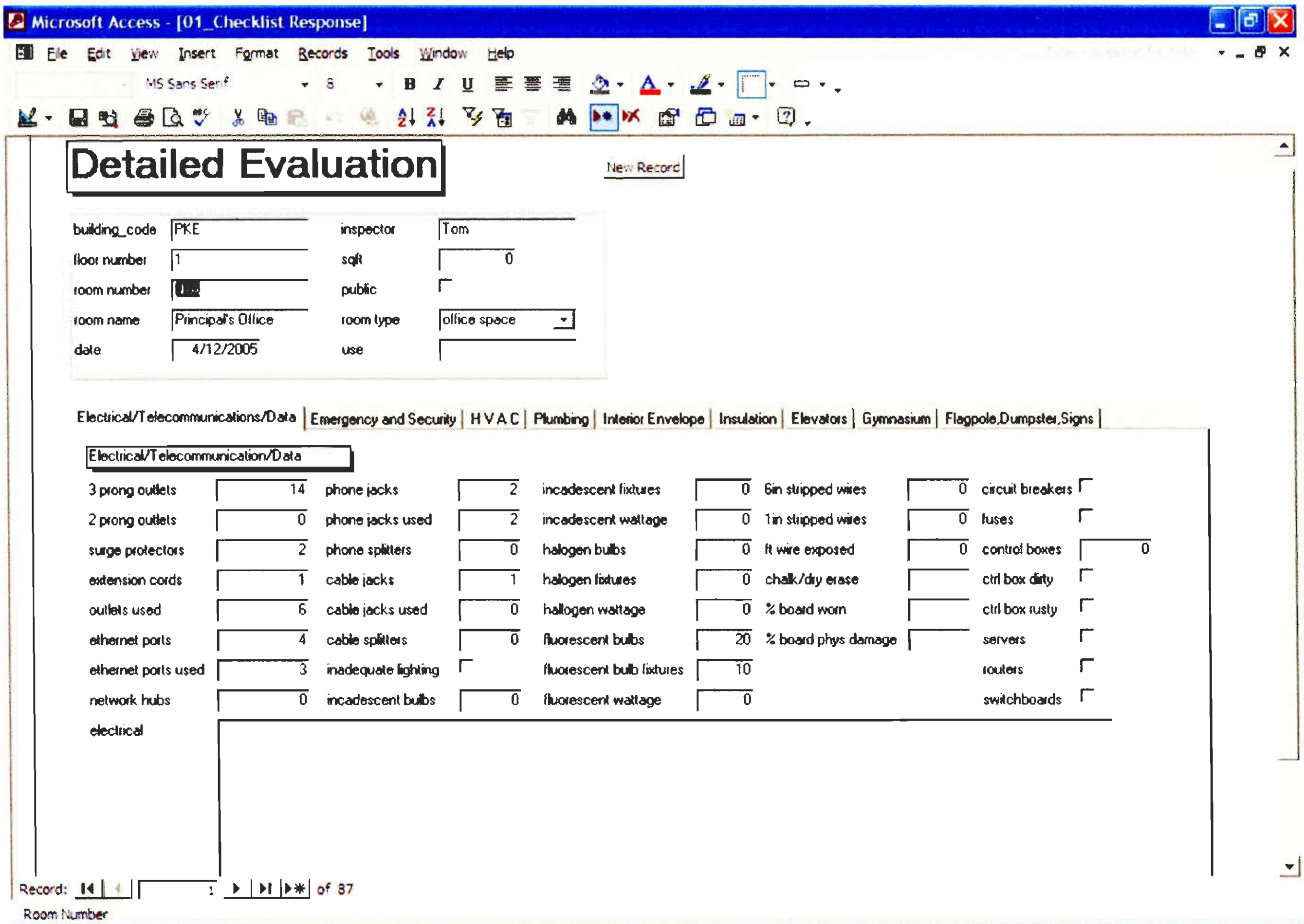

Figure 9: Database - Detailed Evaluation Form

The entries in the electronic form are in the exact same order as those in the paper form to make it convenient for the user to input data. The form is broken up with tabs, into the main sections of the detailed form, to keep the entire form on the screen and keep things simple for the user. When the form is completely filled out, "New Record" can be clicked again and the data for the next room can be entered. The information previously entered is not lost, but is automatically saved in the "Checklist Response" table.

Each saved record can be viewed by going to the original window and clicking "Tables" under "Objects" (See Figure 10). After the tables are opened, click on "Checklist Response" and each form that has been entered will pop up on the screen.

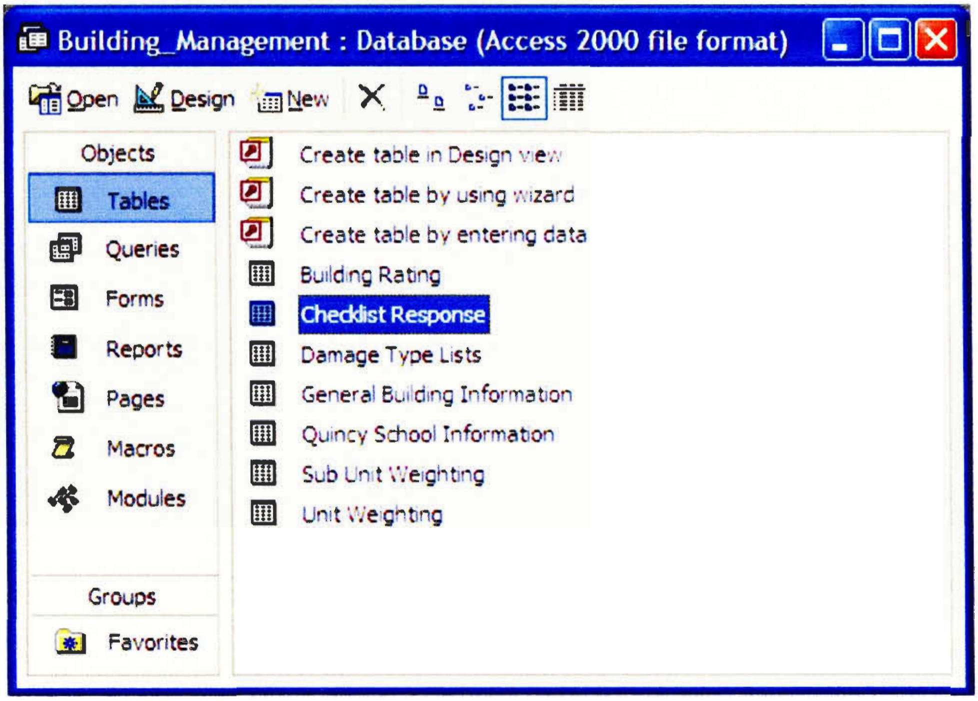

Figure 10: Main Database Window - Tables

The "Checklist Response" table is very large and viewing it as a table will simply show a mess of numbers and check boxes. The best way to view any type of particular information is through "Reports" under "Objects" on the main screen. This will be described later. After all of the data has been entered into the forms, all of the queries must be run so that a ranking will be created for each room. Queries are where all of the formulas for the database are stored, and where all of the rankings for the room are calculated. They are accessed by clicking "Queries" under "Objects" (See Figure 11). To run the queries, simply double-click each one. Two messages will pop up warning the user that they are about to run a query and that the process is irreversible. Click yes to both warning messages (Figures 12 and 13) and the query and all the formulas within the query will run. To get an overall room ranking, every query must be double-clicked and run so that every formula is used. To view the formula contained in a query, click on the query once and click "Design" at the top of the window (See Figure 14).

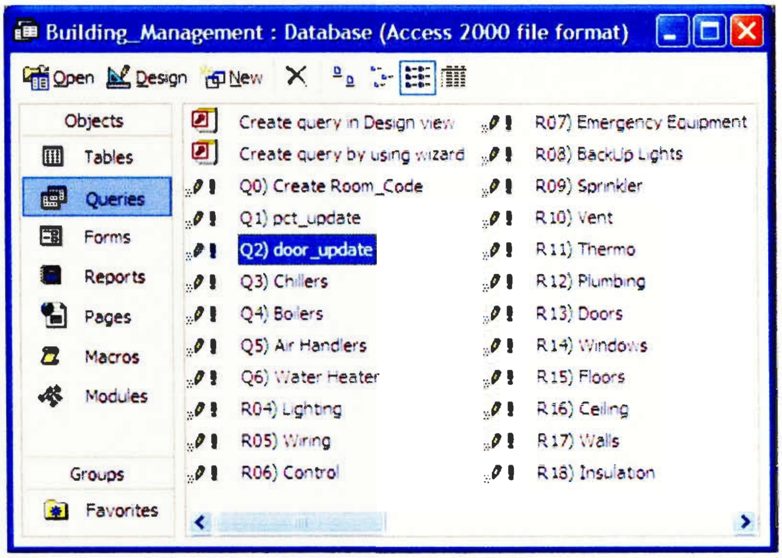

Figure 11: Main Database Window - Queries

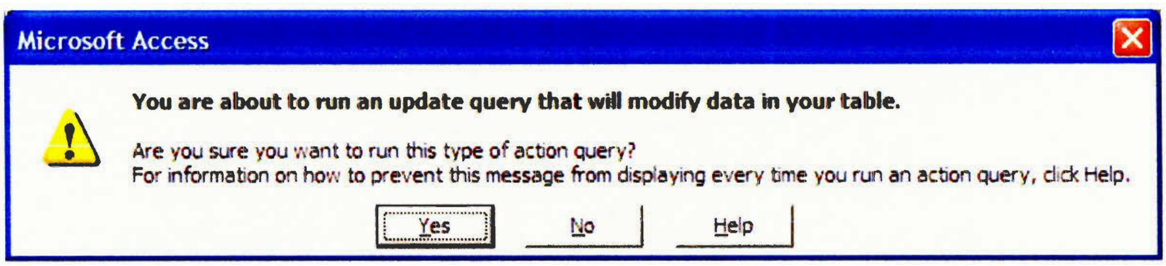

Figure 12: First Query Warning

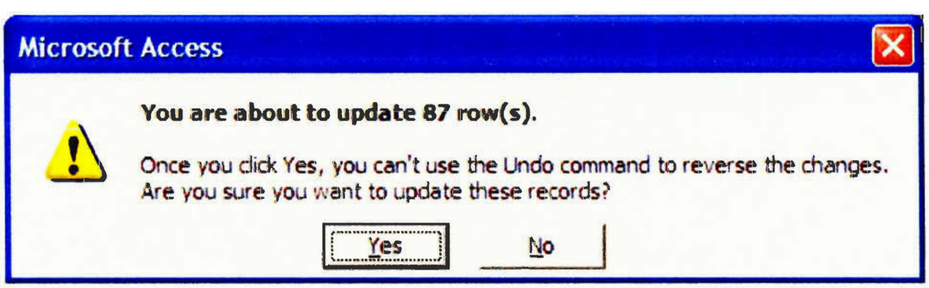

Figure 13: Second Query Warning

On the new window that pops up, go the bottom and look at the row called "Update To". The box may need to be enlarged so that the entire formula can be seen. Here changes can also be made to the formulas (See Figure 15).

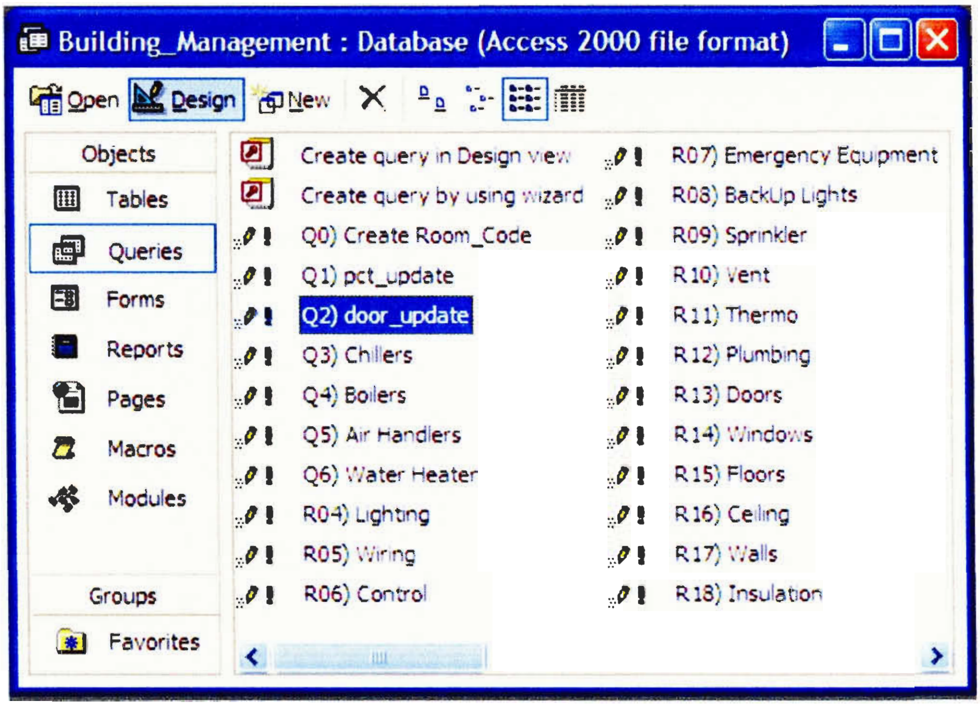

Figure 14: Query Window - Design Button

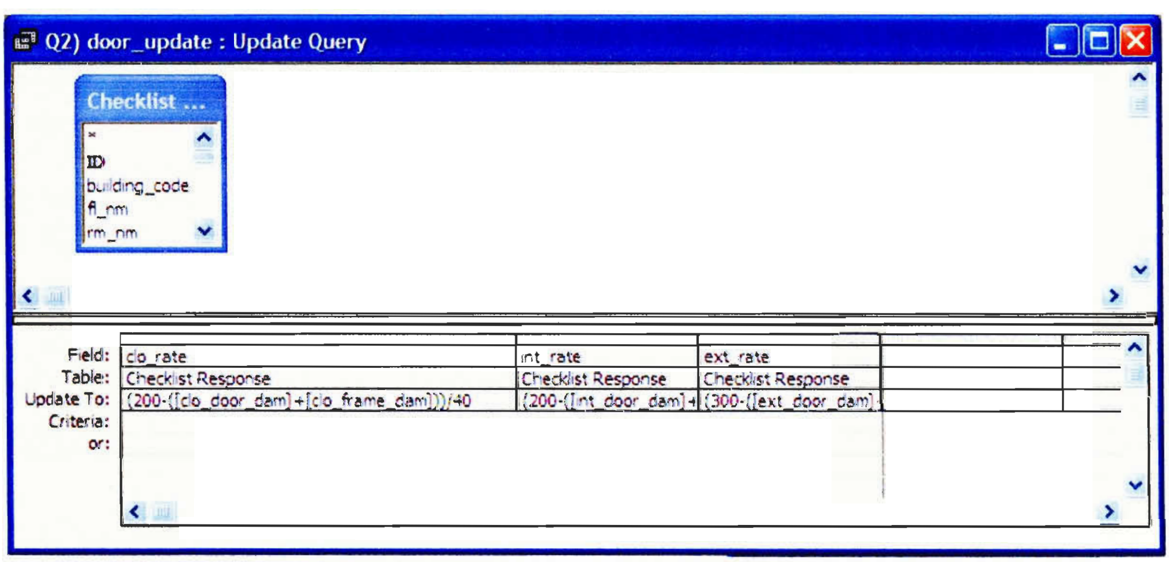

Figure 15: Query Design Window

After all of the queries have been run, the room rankings and any other information wanted are ready for viewing. All of the data goes back to the tables under "Checklist Response". However, the data can more easily be viewed by going to the "Reports" tab under "Objects" (See Figure 16). From the report, all of the data on the ranking of the different rooms can be viewed by double clicking on "Room Rate and Inspection Date" (See Figure 17). There is also a report for the general school information, "Quincy School Information", and the other public buildings in Quincy, "Building Addresses".

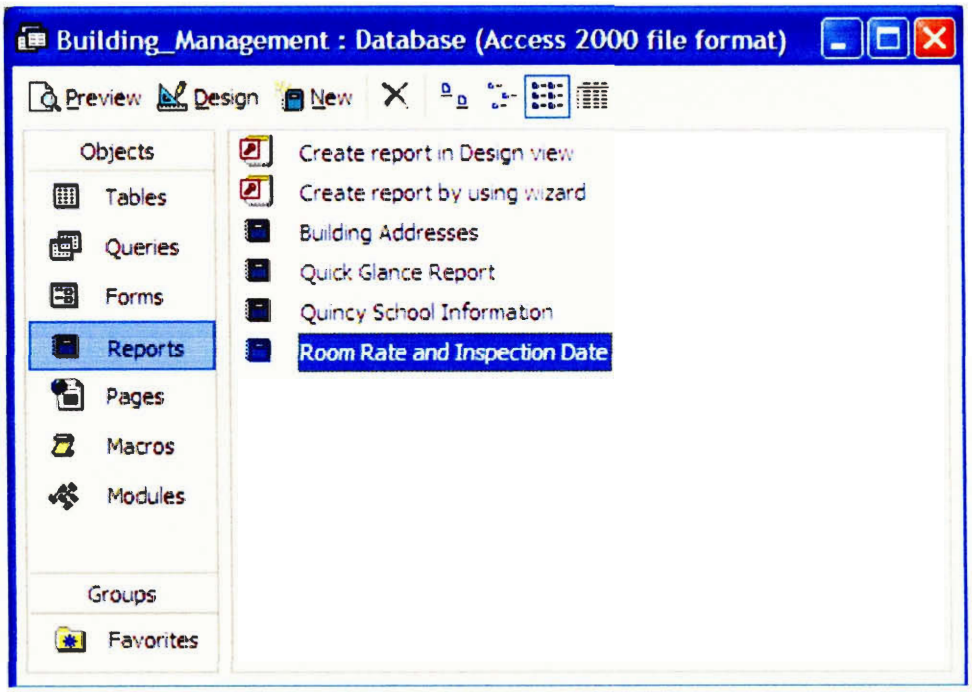

Figure 16: Main Database Window - Reports

Room Rate and Inspection Date

Building Code	Room Code	Room Name	Room Rating	Date
PKE	PKE-1-2	Classroom	3	4/12/20
PKE	PKE-2-14	Classroom	4	4/12/20
PKE	PKE-2-N/A	Hallway Left Side	4	4/12/20
PKE	PKE-Roof-N/A	Roof	3.25	4/12/20
PKE	PKE-0-N/A	Boys Bathroom	4	4/7/201
PKE	PKE-N/A-N/A	Stairwell B	4.2988	4/7/201
PKE	PKE-1-N/A	Principal's Office	4	4/12/20
PKE	PKE-N/A-N/A	Stairwell G	4	4/7/201
PKE	PKE-0-N/A	Hallway	4	4/7/201
PKE	PKE-0-N/A	Hallway- Kitchen/Gym	5	4/7/201

Figure 17: Sample Room Rating Report

This database is not limited to the tables, queries, forms, and reports that are shown on the main screen boxes above. This database can be continually updated and changed to suit the needs of the users. The above instructions will help anyone input data, but someone with some working knowledge of Microsoft Access will be needed to change or modify the database.

Appendix E: Database Variables

Table 8: Database Variables

Variable Name (as it appears in database formulas (if applicable))	Variable Meaning
Eletrical/Telecommunications/Data	
3 prong outlets (3_outlet_ct)	# of 3 prong outlets
2 prong outlets (2_outlet)	# of 2 prong outlets
Surge protectors	# of surge protectors in use
Extension cords	# of extension cords in use
Outlets used (outlet_use)	# of outlets in use
Ethernet ports (port_ct)	# of Ethernet ports
Ethernet ports used (port_ct)	# of Ethernet ports in use
Network hubs (hub_ct)	# of network hubs
Phone jacks (phone_ct)	# of phone jacks
Phone jacks used (phone_use)	# of phone jacks in use
Phone splitters	# of phone splitters
Cable jacks (cable_ct)	# of cable jacks
Cable jacks used (cable_use)	# of cable jacks in use
Cable splitters	# of cable splitters in use
Inadequate lighting (inad_light)	Is there inadequate lighting in room?
Incandescent bulbs	# of incandescent bulbs in room
Incandescent fixtures	# of incandescent light fixtures in room
Incandescent wattage	Wattage of incandescent bulbs
Halogen bulbs	# of halogen bulbs
Halogen fixtures	# of halogen light fixtures
Halogen wattage	Wattage of halogen bulbs
Fluorescent bulbs	# of fluorescent bulbs
Fluorescent bulb fixtures	# of fluorescent light fixtures
Fluorescent wattage	Wattage of fluorescent bulbs
6in stripped wires (wire_6)	# of wires that are stripped more than 6 in.
1in stripped wires (wire_1)	# of wires that are stripped more than 1 in.
Ft wire exposed (wire_exposed)	# of feet of wire exposed
Chalk/dry erase	What kind of board in classroom? Chalkboard or dry erase board?
% board worn	% of the board that is worn

% board phys damage	% of the board that is physically damaged
Circuit breakers (not_label_breaker)	Is circuit breaker labeled properly?
Fuses (fuse)	Is there a fuse box in room?
Control boxes (ctrl_box_ct)	# of control boxes in room
Ctrl box dirty (ctrl_box_dirt)	Is control box dirty?
Ctrl box rusty (ctrl_box_rust)	Is control box rusty?
Servers	Are there servers in room?
Routers	Are there routers in room?
Switchboards	Are there switchboards in room?
Emergency and Security	
Fire alarm switches (switch_ct)	# of fire alarm switches in room
Fire alarm sirens (siren_ct)	# of fire alarm sirens in room
Smoke detectors (detector_ct)	# of smoke detectors in room
Cameras (camera_ct)	# of cameras in room
Fire Extinguishers (extinguisher_ct)	# of fire extinguishers in room
Exit signs (exit_ct)	# of exit signs in room
Back-up lights (bkup_light_ct)	# of back up lights in room
Generator	Is there a generator in room?
Generator test labeled	Is there documentation for the last time the generator was tested?
Generator tested	Has the generator been tested recently?
Generator broken	Is generator broken?
Sprinklers	Are there sprinklers present in room (for fire)?
Inadequate sprinklers (inad_sprinkler)	Is there an inadequate number of sprinklers in room?
Type fence	What type of fence is on school grounds?
% fence damaged	% of fence that is damaged
HVAC	
Vents (vent_ct)	# of vents in room
% vents blocked	% of vents that is blocked
Total vent area	Total vent area
Mold present	Is there mold present on vents?
Heaters	# of space heaters in room
Radiators	# of radiators in room
Baseboards	# of baseboard heaters in room
Thermostats	# of thermostats in room

Mold hvac	Is there mold present on any HVAC equipment?
Room temperature	What is the room temperature?
Temp match thermostat (no_match)	Does the room temperature match the thermostat temperature?
Boilers (boiler_ct)	# of boilers in room
% rust boilers (boiler_rust)	% of boilers that are rusty
Boiler insulation (boiler_insul)	Is there insulation present on boilers?
% jacket separated (boiler_jacket)	% of boiler jacket that is separated from the boiler
Boiler dirty (boiler_dirt)	Is the boiler dirty?
Boiler pipe insulated (boiler_pipe_insul)	Are the pipes coming out of boiler insulated?
Pipe supports damaged	Are the pipe supports for the boiler damaged?
Pipe leaks	Do the boiler pipes leak?
Air handling units (air_ct)	# of air-handling units
Air handling units dirty (air_dirt)	Are the air-handling units dirty?
Units hinges rusty (hinge_rust)	Are the hinges on the air-handling units rusty?
Unit hinges separated (hinge_separate)	Are the hinges separated from the unit?
Units noisy (noise)	Are the air-handling units noisy?
Hot water tanks	# of hot water tanks
Water tanks rusty	Are the water tanks rusty?
Units improperly labeled	Are any of the units in the room improperly labeled?
Chillers (chiller_ct)	# of chillers
Chillers rusty (chiller_rust)	Are the chillers rusty?
Chiller insulation damaged (chiller_insul)	Is the chiller insulation damaged?
% chiller jacket separated (chiller_jacket)	% of chiller jacket that is separated from the chiller
Chillers dirty (chiller_dirty)	Are the chillers dirty?
Pipe insulation damaged (chiller_pipe_insul)	Is the chiller pipe insulation damaged
Pipe supports damaged (chiller_pipe_hw)	Are the pipe supports for the chiller damaged?
Chiller coils damaged (chiller_coil)	Are the chiller coils damaged?
Chiller coils dirty (chiller_coil_dirty)	Are the chiller coils dirty?
Plumbing	
Plumbing leaking (plumbing_leak)	Are there any leaks in the plumbing?
Drinking fountains	# of drinking fountains

Showers	# of showers
Toilets	# of toilets
Urinals	# of urinals
Faucets	# of faucets
Drains	# of drains
Interior Envelope	
Exterior doors (ext_door_ct)	# of exterior doors
% ext door damaged (ext_door_dam)	% of the exterior door that is damaged
% ext frame damaged (ext_frame_dam)	% of exterior door frame that is damaged
Ext weather stripping (ext_weather)	Do exterior doors have weather stripping?
Interior doors (int_door_ct)	# of interior doors
% int doors damaged (int_door_dam)	% of interior door that is damaged
% int frame damaged (int_frame_dam)	% of interior door frame that is damaged
Closet doors (clo_door_ct)	# of closet doors
% clst door damaged (clo_door_dam)	% of closet door that is damaged
%clst frame damaged (clo_frame_dam)	% of closet door frames that are damaged
Locks on doors (lock_ct)	# of doors with locks
Locks broken (lock_broken)	# of door locks that are broken
Doors broken	# of doors that are broken
Interior glass (int_glass_ct)	# of panes of interior glass
Interior glass damaged (int_glass_dam)	% of interior glass that is damaged
Exterior glass (ext_glass_ct)	# of panes of exterior glass
Exterior glass damaged (ext_glass_dam)	% of exterior glass that is damaged
Ext glass multi-paned (ext_glass_multi)	Is exterior glass mult-paned?
Wrst floor rating (wrst_floor)	Rating of the worst part of the floor in a room
% wrst floor (pct_wrst_floor)	% that this worst part covers of the overall floor
Floor damage	Type of floor damage
Rest floor rating (rst_floor)	Rating of rest of floor
Mold floor	Is mold present on floor?
Wrst ceiling rating (wrst_ceiling)	Rating of the worst part of the ceiling in a room
% wrst ceiling (pct_wrst_ceiling)	% that this worst part covers of the overall ceiling
Ceiling damage	Type of ceiling damage
Rest ceiling rating (rst_ceiling)	Rating of rest of ceiling
Mold ceiling	Is mold present on ceiling?
Wrst wall rating (wrst_wall)	Rating of the worst part of the floor in a room

% wrst wall (pct_wrst_wall)	% that this worst part covers of the overall wall
Wall damage	Type of wall damage
Rest wall rating (rst_wall)	Rating of rest of wall
Mold wall	Is mold present on walls?
Insulation	
Wrst insulation rating (wrst_insul)	Rating of the worst part of the floor in a room
% wrst insulation (pct_wrst_insul)	% that this worst part covers of overall insulation
Insulation damage	Type of insulation damage
Rest insulation rating (rst_insul)	Rating of rest of insulation
Insulation type	What kind of insulation is present in room?
Mold insulation	Is mold present in insulation?
Elevators	
Elevators	# of elevators in room
Floors reached	# of floors that elevator services
Serviced properly	Has the elevator been services properly?
Elevator in room	Are elevators present in room?
Gymnasium	
Type bleachers	What type of bleachers are present in gym?
Rail guards present	Are rail guards present on bleachers?
% bleachers damaged	% of bleachers that are damaged
Backstop padding	Is backstop padding present on walls?
% padding damaged	% of backstop padding that is damaged
Bsktbll goal damaged	Are any of the basketball hoops damaged?
Flagpole, Dumpsters, Signs	
Flagpoles	# of flagpoles present outside
Flagpole material	What type of material is the flagpole made of?
% paint deteriorated	% of paint on flagpole that is deteriorating or deteriorated
% flagpole rusty	% of flagpole that is rusty
Flagpole damaged	Is flagpole physically damaged?
% foundation damaged	% of foundation on building that is damaged
Dumpster surface	What kind of surface is the dumpster sitting on?
Dumpsters enclosed	Is the dumpster enclosed?
Interfere w/cars, ped	Do the dumpsters interfere with cars or

	pedestrians?
Locked enclosure	Does the enclosure lock?
Signs present	Are there signs present outside the school?
Signs clearview readable	Are the signs in clear view and are they readable?
% signs damaged	% of the signs that are damaged.

Appendix F: Database Formulas

Table 9: Database Formulae

Formula Name	Meaning of Formula	Complete Formula	Rationale for Formula
Q1) pct_update			
pct_port	% of ethernet ports that are in use	([port_use]/[port_ct])*100	Dividing ports used by total ports, % of ports in use is obtained.
pct_cable	% of cable ports that are in use	([cable_use]/[cable_ct])*100	Dividing cable ports in use by total cable ports, % of ports in use is obtained.
pct_outlet	% of electrical outlets that are in use	(([outlet_use]/([3_outlet_ct])+([2_outlet])))*100	Dividing outlets used by total outlets, % of outlets in use is obtained.
pct_phone	% of phone jacks that are in use	([phone_use]/[phone_ct])*100	Dividing phones in use by total phones, % of phone jacks in use is obtained.
pct_weather	% of exterior doors with weather stripping	(IIf([ext_door_ct]=0,100,(([ext_weather]/[ext_door_ct])*100)))	If there are no exterior doors, percent=100. If there are exterior doors, divide exterior doors with weather stripping by total exterior doors to get % of exterior doors with weather stripping.
pct_lock	Rating of locks on doors (scale 0-5), based on percentage of locks that are broken	IIf([lock_ct]=0,5,5-(([lock_broken]/[lock_ct])*5))	If there are no locks, the rating is a 5. If there are locks, the percentage of locks that are broken is multiplied by 5. This number is then subtracted from 5 to get a rating for door locks.
pct_door	Rating of doors based on how many are broken (scale 0-5)	IIf(([ext_door_ct]+[int_door_ct]+[clo_door_ct])=0,5,(5-(([door_broken]/([ext_door_ct] +[int_door_ct]+[clo_door_ct]))*5)))	If there are no doors in room, rating is a 5. If there are doors, then the percentage of doors that are broken is multiplied by 5, and then this number is subtracted from 5 to get a rating for the doors based on how many are broken.
pct_hub	% of network hubs being used with total ethernet ports	(([hub_ct]/[port_ct]))*100	Dividing number of network hubs by total number of Ethernet ports, % of network hubs being used with Ethernet ports is obtained.

Q2) Door Update			
clo-rate	Rating of closet doors in room (scale 0-5)	(200-([clo_door_dam]+[clo_frame_dam]))/40	200-100-100=0 200/40=5
int-rate	Rating of interior doors in room (scale 0-5)	(200-([int_door_dam]+[int_frame_dam]))/40	200-100-100=0 200/40=5
ext_rate	Rating of exterior doors in room (scale 0-5)	(300-([ext_door_dam]+[ext_frame_dam]+(100-[pct_weather])))/60	200-100-100=0 200/40=5
Q3) Chillers			
chiller_rate	Overall rating of chillers in room (scale 0-5)	(((IIf([chiller_rust]>20,0,1)+IIf([chiller_insul],0,1)+IIf([chiller_dirt],0,1)+IIf([chiller_pipe_insul],0,1)+IIf([chiller_pipe_hw],0,1)+IIf([chiller_coil],0,1)+IIf([chiller_coil_dirt],0,1)+IIf([chiller_jacket]>20,0,1))/8)*5)	If rust covers more than 20%, rating is a 0, otherwise a 1. If there is chiller insulation, rating is a 1, otherwise a 0. If chiller is dirty, rating is a 0, otherwise a 1. If there is chiller pipe insulation, rating is a 1, otherwise a 0. If pipe supports are damaged, rating is 0, otherwise a 1. If chiller coils are damaged, rating is a 0, otherwise a 1. If chiller coils are dirty, rating is a 0, otherwise a 1. If more than 20% of the chiller jacket is separating from the chiller, rating is a 0, otherwise a 1. All of these numbers are then divided by 8 to get a percentage and then multiplied by the maximum rank, which is a 5.
Q4) Boilers			
boiler_rate	Overall rating of boilers in room (scale 0-5)	(((IIf([boiler_rust]>20,0,1)+IIf([boiler_insul],0,1)+IIf([boiler_dirt],0,1)+IIf([boiler_pipe_insul],0,1)+IIf([boiler_pipe_hw],0,1)+IIf([boiler_jacket]>20,0,1))/6)*5)	If rust covers more than 20% of boiler, rating is a 0, otherwise a 1. If there is boiler insulation rating is a 1, otherwise 0…etc. These numbers are divided by 6 to get a percentage and then multiplied by the maximum rank, which is a 5.
Q5) Air Handlers			
air_rate	Overall rating of air handlers in room (scale 0-5)	(((IIf([hinge_rust],0,1)+IIf([air_dirt],0,1)+IIf([noise],0,1)+IIf([hinge_seperate],0,1))/4)*5)	If hinges are rusty, rating is a 0, otherwise a 1…etc. These numbers are divided by 4 to get a percentage and then multiplied by the maximum rank, which is a 5.
R04) Lighting			
rate_light	Overall rating of lighting in room	IIf([inad_light],0,5)	If room has inadequate lighting, rank is a 0, otherwise a 5.

	(scale 0-5)		
R05) Wiring			
rate_wire	Overall rating of wiring in room (scale 0-5)	((IIf([wire_6]>0,0,7))+(IIf([wire_1]>0,0,2))+(IIf([wire_exposed]>0,0,1)))/2	If the number of wires stripped more than 6 inches is greater than 0, rank is a 0, otherwise it is a 7. If the number of wires stripped more than 1 inch is greater than 0, rank is a 0, otherwise a 2. If there are any wires exposed, rank is a 0, otherwise a 1. Since 7+2+1=10, if there are no wires exposed, the overall rank will be a 5 because all of these numbers are divided by 2.
R06) Control			
rate_ctrl	Overall rating of control boxes in room (scale 0-5)	5-((IIf([ctrl_box_rust],2,0))+(IIf([ctrl_box_dirt],0.5,0))+(IIf([fuse],2,0))+(IIf([not_label_breaker],0.5,0)))	If control box is rusty, formula outputs a 2, otherwise a 0. If control box is dirty, output is a 0.5, otherwise a 0...etc. These numbers are then subtracted from 5 to get an overall rank. If all of the outputs to these questions are 0, then the overall rank will 5-0=5.
R07) Emergency Equipment			
rate_emr_basic	Overall rating of emergency equipment in room (scale 0-5)	IIf((IIf([switch_ct]>0,1,0)+IIf([siren_ct]>0,1,0)+IIf([detector_ct]>0,1,0)+IIf([sensor_ct]>0,1,0)+IIf([exit_ct]>0,1,0)+IIf([extinguisher_ct]>0,1,0)+IIf([camera_ct]>0,1,0))>0,5,0)	If there is any kind of emergency equipment in the room such as fire switches, fire sirens, fire extinguishers, or smoke detectors, then the room gets a rank of 5 for emergency equipment. The room gets this rating for emergency equipment because chances are if there is any of this equipment present, then the room is prepared for a fire emergency. If the room has none of this equipment, the rank comes out to be a 0 because the room is not equipped for an emergency.
R08) Back Up Lights			
rate_bkup_light	Overall rating of backup lights in room (scale 0-5)	IIf([bkup_light_ct]>0,5,0)	If room has backup lights, it gets a ranking of 5, otherwise it gets a rating of 0.
R09) Sprinkler			
rate_sprinkler	Overall rating of sprinkler system in room (scale 0-5)	IIf([inad_sprinkler],0,5)	If the room has inadequate sprinklers for a fire emergency, then it gets a rank of 0. If there is an adequate amount of sprinklers, then the room gets a rank of 5.

R10) Vent			
rate_vent	Overall rating of ventilation in room (scale 1-5)	IIf([vent_ct]=0,1,5)	If there is no ventilation in room, rank is a 0, otherwise a rank of 5.
R11) Thermo			
rate_thermo	Overall rating of thermostats in room (scale 1-5)	IIf([no_match],0,5)	If thermostat temperature does not match temperature in room, rank is a 0, if it does match then the rank is a 5.
R12) Plumbing			
rate_plumbing	Overall rating of plumbing in room (scale 1-5)	IIf([plumbing_leak],0,5)	If any plumbing in the room leaks, the rank is a 0, if there are no leaks the rank is a 5.
R13) Doors			
rate_door	Overall rating of all doors in room (scale 1-5)	((([ext_rate]+[pct_door]+[pct_lock])*2)+[int_rate]+[clo_rate])/8	Ratings from all the doors and locks are added. If all five of these rankings equal 5, then they will add up to 40. Dividing 40 by 8, the maximum rank of 5 is obtained.
R14) Windows			
rate_window	Overall rating of windows in room (scale 1-5)	(200-([ext_glass_dam]+[int_glass_dam]))/40	
R15) Floor			
rate_floor	Overall rating of floor in room (scale 1-5)	IIf([pct_wrst_floor] Between 33 And 101,[wrst_floor],([wrst_floor]*((100-[pct_wrst_floor])/100)+[rst_floor])/2)	If worst part ranking of floor covers more than 33%, then the overall floor rating is the worst part ranking. If it is less than 33%, then the worst part rank is multiplied by (100-% the worst part covers), then added to the rest of the floor ranking. All these numbers added together are then divided by 2 to get a ranking of 1-5.
R16) Ceiling			
rate_ceil	Overall rating of ceiling in room (scale 1-5)	IIf([pct_wrst_ceiling] Between 33 And 101,[wrst_ceiling],([wrst_ceiling]*((100-[pct_wrst_ceiling])/100)+[rst_ceiling])/2)	See rate_floor
R17) Walls			
rate_wall	Overall rating of walls in room (scale 1-5)	IIf([pct_wrst_wall] Between 33 And 101,[wrst_wall],([wrst_wall]*((100-[pct_wrst_wall])/100)+[rst_wall])/2)	See rate_floor

R18) Insulation			
rate_insul	Overall rating of insulation in room (scale 1-5)	IIf([wrst_insul] Between 50 And 101,[wrst_insul],([wrst_insul]*((100-[pct_wrst_insul])/100)+[rst_insul])/2)	Same as floor rating, except 50 is used instead of 33 since maintaining insulation is not as pressing as maintaining a ceiling, floor, or wall.
U1) Electric			
rate_electric	Overall rating of electric system in room (scale 1-5)	(40*[rate_light]+40*[rate_wire]+20*[rate_ctrl])/100	The rate of the lighting is multiplied by 40, the rate of the wiring by 40, and the rate of the controls by 20. The lighting and wiring are given higher numbers because they are more important to the functionality of the room than the control boxes. These numbers added together are then divided by 100 to get a ranking of 1-5.
U2) emergency			
rate_emr_scr	Overall rating of emergency system in room (scale 1-5)	((69*[rate_emr_basic])+(8*[rate_bkup_light])+(23*[rate_sprinkler]))/100	Similar to rating of electric system except different variables and weights are used. The rating of the emergency equipment is rated very high at 69 because it is obviously very important for safety. Sprinklers are also rated higher than backup lights because they are more important to the safety of the people in the room than backup lights. These numbers are divided by 100 to get a ranking of 1-5.
U3) HVAC			
rate_hvac	Overall rating of HVAC system in room (scale 1-5)	(15*[chiller_rate]+25*[boiler_rate]+15*[air_rate]+15*[water_rate]+15*[rate_thermo]+15*[rate_vent])/100	Similar to rating of electric system except different variables and weights used. Boiler is rated slightly higher than everything else because boilers must be constantly maintained to make sure that the building has heat.
U4) Plumbing			
rate_plumb	Overall rating of plumbing in room (scale 1-5)	[rate_plumbing]	The overall rating of the plumbing is the same as [rate_plumbing] that was defined in section R12.
U5) Envelope			
rate_int_env	Overall rating of interior envelope in room (scale 1-5)	((16*[rate_ceil])+(32*[rate_door])+(8*[rate_floor])+(28*[rate_window])+(16*[rate_wall]))/100	Similar to rating of electric system except different variables and weights used. Doors and windows are rated higher because they must be constantly maintained to prevent heat loss. Floors are rated lower because repairing floors is not as urgent as repairing other elements of the interior envelope.
W0) Electric			
weight_electric	Weight of rating	IIf([rm_type]="lavatory",19,IIf([rm_type]="exterior",	Formula assigns a certain weight of the electric system

	of electric system in room, depending on what type of room it is	30,IIf([rm_type]="general public",24,IIf([rm_type]="office space",24,IIf([rm_type]="roof",10,IIf([rm_type]="storage",24,IIf([rm_type]="auditorium",35,IIf([rm_type]="cafeteria/kitchen",34,IIf([rm_type]="classroom",24,IIf([rm_type]="gymnasium",19,IIf([rm_type]="pc room",50,IIf([rm_type]="utility",28,IIf([rm_type]="library",24,IIf([rm_type]="multipurpose",24,24)))))))))))))))	depending on the type of room. Rooms to note are the PC room and the boiler room, where the ranking of the electrical system is higher. The electric system is very important in PC rooms for the obvious reason that this room has a lot of electronic equipment. The electric system is also very important in the utility room, where there is a lot of equipment that requires electricity to run.
W1) Emergency			
weight_emr_scr	Weight of rating of emergency system in room, depending on what type of room it is	IIf([rm_type]="lavatory",9,IIf([rm_type]="exterior",6,IIf([rm_type]="general public",24,IIf([rm_type]="office space",24,IIf([rm_type]="roof",5,IIf([rm_type]="storage",16,IIf([rm_type]="auditorium",24,IIf([rm_type]="cafeteria/kitchen",24,IIf([rm_type]="classroom",24,IIf([rm_type]="gymnasium",24,IIf([rm_type]="pc room",24,IIf([rm_type]="utility",16,IIf([rm_type]="library",24,IIf([rm_type]="multipurpose",24,24))))))))))))))	Assigns weight for emergency system based on type of room. Weights are very similar for most rooms, except for roof, where emergency equipment is not as important because people do not spend time on the roof.
W2) HVAC			
weight_hvac	Weight of rating of HVAC system in room, depending on what type of room it is	IIf([rm_type]="lavatory",14,IIf([rm_type]="exterior",15,IIf([rm_type]="general public",15,IIf([rm_type]="office space",15,IIf([rm_type]="roof",0,IIf([rm_type]="storage",20,IIf([rm_type]="auditorium",20,IIf([rm_type]="cafeteria/kitchen",20,IIf([rm_type]="classroom",15,IIf([rm_type]="gymnasium",15,IIf([rm_type]="pc room",10,IIf([rm_type]="utility",20,IIf([rm_type]="library",15,IIf([rm_type]="multipurpose",15,15))))))))))))))	Assigns weight for HVAC system based on type of room. Weights are very similar for most rooms, except for roof, where there is no HVAC equipment stored, and ventilation is obviously not an issue.
W3) Plumbing			
weight_plumb	Weight of rating of plumbing	IIf([rm_type]="lavatory",38,IIf([rm_type]="exterior",19,IIf([rm_type]="general	Assigns weight for plumbing based on type of room. Plumbing is given a higher rating in lavatories because of the toilets,

	system in room, depending on what type of room it is	public",7,IIf([rm_type]="office space",7,IIf([rm_type]="roof",10,IIf([rm_type]="storage",12,IIf([rm_type]="auditorium",7,IIf([rm_type]="cafeteria/kitchen",7,IIf([rm_type]="classroom",7,IIf([rm_type]="gymnasium",7,IIf([rm_type]="pc room",7,IIf([rm_type]="utility",30,IIf([rm_type]="library",7,IIf([rm_type]="multipurpose",7,7)))))))))))))	sinks, and drains present. Plumbing is given a lower ranking in other types of rooms because there is not a great deal of plumbing present in these rooms.
W4) Interior Envelope			
weight_int_env	Weight of rating of interior envelope in room, depending on what type of room it is	IIf([rm_type]="lavatory",20,IIf([rm_type]="exterior",30,IIf([rm_type]="general public",30,IIf([rm_type]="office space",30,IIf([rm_type]="roof",75,IIf([rm_type]="storage",28,IIf([rm_type]="auditorium",19,IIf([rm_type]="cafeteria/kitchen",15,IIf([rm_type]="classroom",19,IIf([rm_type]="gymnasium",35,IIf([rm_type]="pc room",9,IIf([rm_type]="utility",6,IIf([rm_type]="library",19,IIf([rm_type]="multipurpose",19,19))))))))))))))	Assigns weight for interior envelope based on type or room. Envelope is given a very high rank for the roof because it is very important that the roof covering be properly maintained to prevent leaks. The weight of the envelope is very low in the utility room because it is not as important to maintain the envelope in this room based on the fact that not many people go inside the utility room. Envelope is given a relatively high ranking for all other rooms because it is important to maintain for the safely of all occupants of these rooms.
X1) Room Rating			
rate_room	Overall room rating (scale 1-5)	IIf([pct_wrst_floor] Between 33 And 101,[wrst_floor],IIf([pct_wrst_ceiling] Between 33 And 101,[wrst_ceiling],IIf([pct_wrst_wall] Between 33 And 101,[wrst_wall],(([rate_electric]*[weight_electric])+([rate_emr_scr]*[weight_emr_scr])+([rate_hvac]*[weight_hvac])+([rate_plumb]*[weight_plumb])+([rate_int_env]*[weight_int_env]))/100)))	If the worst part of the floor, ceiling, or wall covers more than 33% of the overall part, then the whole room ranking should be this worst part rating. If the worst part of a wall, floor, or ceiling covers this much space, then there will be other maintenance problems in the room and so the overall ranking should show this. If the worst part covers less than 33% in all of these parts of the room, then the rating of each aspect of the room is multiplied by its weight. The sum of all these numbers is then divided by 100 to get a ranking of 1-5. If all of the ratings were a perfect 5, then the numerator would add up to 500 and dividing this number by 100 would give a perfect room rating of 5.