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Grounds Maintenance at Worcester Polytechnic Institute

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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Abstract

This project was designed to continue to improve the grounds maintenance process at WPI by continuing the efforts and taking the next step of previous E-Grounds projects. In doing so, the pertinent information should be organized and computerized in a proper fashion. The next step in the overall goal of computerizing the grounds maintenance information for WPI was doing a complete analysis on the lawn maintenance at WPI and computerizing the related information. To complete this goal, lawn tasks and service levels were mapped out and extensively analyzed to determine the resources required to maintain WPI's lawns in a desired fashion.

Acknowledgements

We would like to thank project sponsor, WPI Plant Services, for their help and support throughout this project; in particular, Ronald Klocek and his crew for their repeated knowledge of information to help make this project run smoothly and effectively. Also, we would like to thank the project advisors Fabio Carrera, John Miller, and Guillermo Salazar for their support and knowledgeable advice throughout this project.

Executive Summary

Grounds maintenance at WPI is no different than on any other college or university campus across the country or throughout the world. Efficiently and effectively maintaining the grounds of the campus is the main concern and responsibility for WPI's plant services department, who heads up the grounds maintenance team.

Prior to the existence of the E-Grounds IQP on the campus of WPI, no measure or evaluation had ever occurred which could go to show at what level of effectiveness or efficiency the grounds maintenance team was operating at in terms of its day to day and seasonal operations. In its first year, the E-Grounds IQP laid the foundation for future projects to take place and go further in depth in terms of analysis and recommendations.

For this section of the E-Grounds IQP, the focus was placed on the lawns of the WPI campus. Taking the information given from last year's project, as well as gathering new information from research allowed this project to take shape and develop statistics and figures for each lawn task and activity associated with lawn maintenance. Levels of service were also established for each lawn as well as equipment used on each lawn based on different activities. With all the necessary information in place, a number of results were obtained regarding lawn maintenance values, the most important being seasonal man-hours for each lawn, all of which are displayed in GIS maps.

Figure 1: Seasonal Man-hours per Lawn

1. Introduction

As recently as 2001, over $190 billion is spent annually in the United States in the field of landscaping and grounds maintenance. There are over 100,000 grounds maintenance and landscaping firms, operating over 110,000 establishments, and employing over a million people in this country.[1] This is a huge industry, and also an ever expansive one, because as the country continues to grow, the necessity for more developed lands grows with it, and therefore the demand for effective and efficient grounds continues to rise. As with any expansive industry, growth challenges have began to become more prominent within the existing firms throughout the nation. Specifically, in a survey conducted by the Landscape Management Organization, growth management came in second place as what would be the biggest management challenge of 2002.[2] Clearly steps need to be taken in the industry to meet these challenges head on.

A major area where grounds maintenance comes to the forefront is at colleges and universities throughout the country. Schools spend hundreds of thousands of dollars annually in attempts to maintain their grounds and present their campus at the highest level possible. The appearance of a college or university is integral in their attempt to attract new and prospective students to the institution, and it is for this reason that such large sums of time and money are spent on a yearly basis trying to improve upon both the management of the grounds as well as the physical appearance. Despite the fact that it is

[1] United States Census Bureau
[2] www.landscapemanagement.net

widely known that there is a correlation between the appearance of a school and the enrollment numbers, it seems that in every almost instance, grounds maintenance budgets are the first to be cut every year, decreasing the resources available to keep the campuses beautiful. It doesn't seem right that the demands and expectations placed upon these grounds maintenance teams are continually rising as the resources they are given are continually decreasing, but that is the reality of the situation they face. It is due to this reality that the grounds maintenance teams at these colleges and universities are managing themselves in the most efficient manner possible, so they can do the best they can with what they have.

The situation is no different for the grounds maintenance team at WPI. The institution is expanding in terms of both enrollment and size, and therefore even more responsibility has been laden upon the grounds maintenance team to perform at the highest levels. Even with the growth in the school, as if with many other schools across the country, the grounds maintenance budget has been cut, and the loss of two employees has reduced their resources and available labor hours significantly. The necessity for a new and improved management and organizational system has come to the forefront. By utilizing the technological resources an institution such as WPI has at its disposal, a completely computerized organizational, scheduling and overall management system is not an unrealistic goal, and is something that could greatly benefit both the grounds maintenance team and the institution as a whole. An improvement in overall grounds maintenance management will lead to a more efficient grounds maintenance operation at WPI, providing both pertinent information regarding the necessary resources to maintain the

grounds, as well as leading to potentially large savings in money and increases in maintenance quality.

2. Background

2.1 Campus Grounds Maintenance

The face of the American college or university has changed throughout the years. What began as an individual building in an agrarian landscape has evolved to a rational organization of buildings that form memorable outdoor spaces, and it is the combination of these spaces and the buildings that consume them, that make a complete campus.

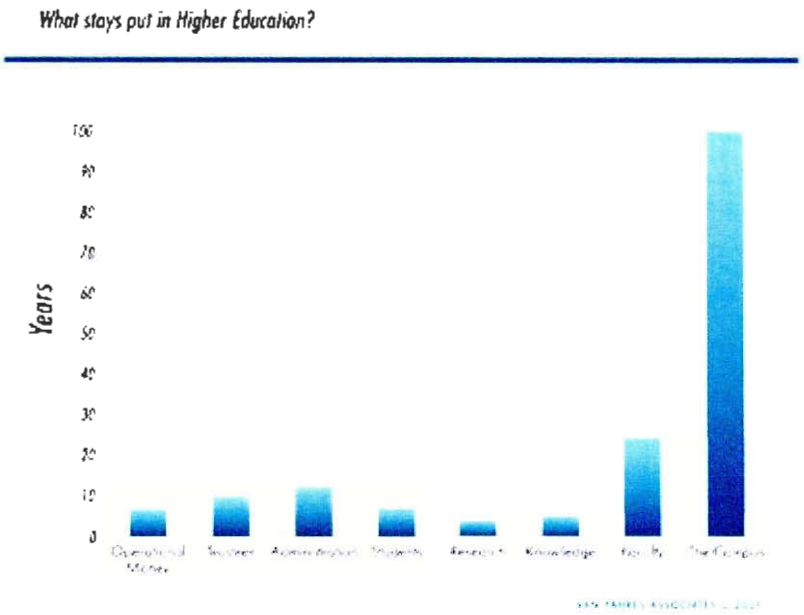

Figure 2: What Stays Put in Higher Education

During the postwar years (World War Two) however, rapid growth of the American campus, coupled with irrational stylishness often led to unfortunate campus development and can be viewed as one of the factors that caused some of the challenges campus

planners face today as they attempt to modernize some of the older campuses throughout the country. The campus is the one constant of a college or university; the students, faculty, curriculum, are all transient functions of the institution, but the campus remains throughout. (Figure 2)

Every new generation of college students is a bit more discerning and sophisticated than the one it is following.

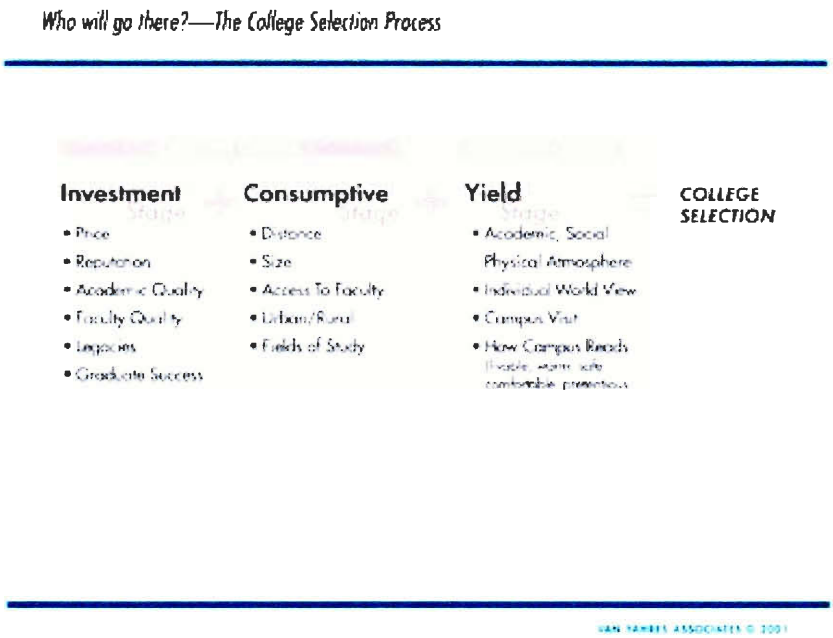

Figure 3: The College Selection Process

What these prospective students see when they first visit a college or university is crucial to their final choice in which institution to attend. (Figure 3) In the process of selecting a college or university, potential students initially consider factors such as investment, reputation and fields of study, thus compiling a short list of schools they are willing to

consider for attending. Only when they personally experience a campus however, will they be likely to make the commitment and investment of a lifetime.

Generally, the American college or university campus is comprised of about 20% buildings and 80% grounds; yet in terms of expenses, 90% of all available money is spent on buildings, leaving only 10% for the grounds and the rest of the campus. Due to this undeniable fact, smart planning and quality efficient maintenance is often more important in creating a widely admired campus than the actual total investment made to do so. (Figure 4)

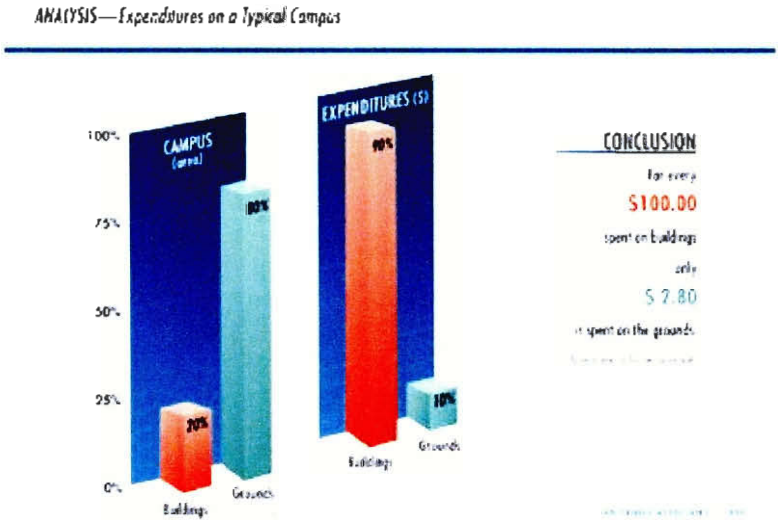

Figure 4: Campus Expenditures

A perfect example of this occurred recently at the University of Wisconsin- River Falls campus (UW-RF). In a student article written by Bridget Bohl entitled "Grounds Maintenance gets lost in budget shuffle", the author goes on to describe a situation that has become far too familiar for college and university campuses across the nation.

UW-RF is in the process of finishing a new student center on its campus, yet despite this, the grounds keeping budget will not be increased to allow for more staffing supplies, even though the new student center will require more maintenance for the surrounding areas of campus. The administration is aware that a trade-off is required if the grounds keeping budget is not increased.

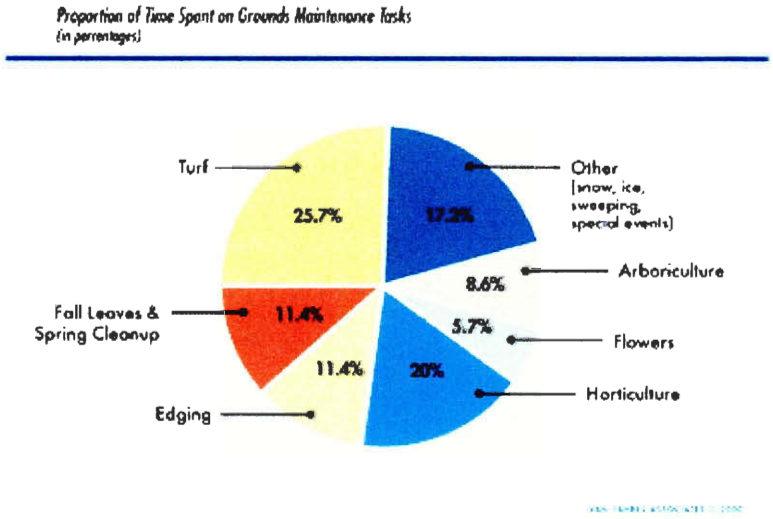

Figure 5: Grounds Maintenance Tasks

Dale Braun, the campus planner is quoted as saying "If money is put into landscaping, something else doesn't get done – as simple as that." He also went on to say that landscaping is usually one of the first things to be cut from the budget. Manny Kenny, the grounds maintenance supervisor at UW-RF said that with the current budget and increased workload; if more workers can't be hired then expectations on campus appearance must be lowered. The article goes on to explain that certain areas of grounds maintenance have been cut back or completely removed. (Figure 5) Facets of landscaping such as the planting of new trees and the use of fertilizer have been completely removed

from the campus said Kenny. It also goes on to say that although there have been no loss in employees of the grounds maintenance teams, they have had to take pay and benefit cuts and it is becoming increasingly harder to perform their jobs at a high level.

The situation at UW-RF paints an accurate and clear picture of the challenges grounds maintenance teams at colleges and universities throughout the country face regularly. Increased workloads, with resource levels either remaining the same or dropping, creates a management of growth issue for these maintenance teams. With all of these apparent management issues, it is clear that steps need to be taken to assist these grounds maintenance teams in managing and organizing their efforts so they can best serve their college or university.

2.2 Facets of Campus Maintenance

2.2.1 Management

The supervisor of the grounds at WPI is Mr. Ronald Klocek. His official title is Manager of Grounds and Properties. Mr. Klocek's job description states that the basic function of his job is to "manage the maintenance of all campus grounds and of properties peripheral to campus." Mr. Klocek has many duties and responsibilities under his job description. He supervises the maintenance of all grounds, athletic fields, and on-site facilities on both the main campus and peripheral properties owned by WPI. Mr. Klocek must report directly to both the Associate Vice President for Business Affairs and the Director of the

Physical Plant at WPI. The Associate Vice President for Business Affairs at WPI is Stephen J. Hebert. The Director of the Physical Plant at WPI is John E. Miller.

Mr. Klocek must also work with Mr. Miller to hire, and train personnel within his division of Plant Services. When any new projects arise to modernize, maintain or upgrade any part of campus grounds, he must head this task. The ordering or new supplies and equipment is headed by Mr. Klocek, as well as the records and operations of all Plant Services vehicles are under his supervision. He is responsible for campus functions such as moving, setting up, and taking down furniture from events. When it snows, he is responsible for campus snow removal and the salting of icy walkway and roadways. Also, he is on-call twenty-four hours for campus emergencies that may arise. Finally he is responsible for nine semi-skilled non-exempt union employees and up to ten student employees. To help fulfill his job requirements he may assign authority to any of the employees.

2.2.2 Employees

Currently there are eight employees to the grounds maintenance team: seven gardeners, and one Gardener/Maintenance Mechanic that specializes in maintenance and fixing equipment around the campus. The seven gardeners are divided into two types of gardeners, Gardener I and Gardener II. Gardener I have taken four college level courses in grounds maintenance and operate under a pesticide license. Gardener II has taken only two college level courses in grounds maintenance.

Mr. Klocek is held directly responsible for the supervision of all eight of these employees and reports directly to John Miller about any pertinent information regarding the grounds maintenance team and its efforts.[3] (See Appendix A for Job Descriptions and Qualifications for Gardener I, II, Maintenance Mechanic, and Groundskeeper)

2.2.3 Lawn Care

The lawns of the WPI campus are maintained similarly for each of the three seasons, spring, summer, and fall. At first during the spring season, workers will go around to remove any branches, twigs, papers, stones and any other debris including sand that may have accumulated over the winter season. They next will have to find any large holes or ruts and fill them with soil to level off the land.

The next step in this spring process is to aerate the lawns in preparation for seeding and fertilizing. After all lawns have been aerated, seeding begins. Due to the winter season there can be tremendous amounts of dead grass and the seeding procedure helps to revitalize all the grass. After seeding, the fertilization process begins. This process will be discussed later on. The final two steps for the spring season are liming (in order to balance acidity and increase pH levels) and to mow the lawn. The lawns are cut to a height of two and a half to three inches.

During the summer months, similar steps are taken to maintain the lawns. First the lawns are cleaned of any debris and then the lawns are cut to a height of two and half to three

[3] E-Grounds IQP; 2004

inches. Approximately one inch of water is added to the lawns per week depending on rainfall and other circumstances. The lawns are checked for substantial amounts of insects. Once a summer the lawns are again aerated and fertilized.[4]

Again, during the fall, branches, twigs, papers, stones, any other accumulated debris is picked up from the lawns. In the fall, the leaves begin to fall off the trees, which require raking and removing from the campus. Prior to mowing the machines are checked for proper operation and again the lawns are mowed to approximately two and a half to three inches. Again, the lawns are aerated and fertilized. To reach the proper pH level the lime is added to the soil.

In all seasons mowing occurs according to need and priority. However some activities may not be completed to their fullest due to resource constraints such as manpower and budget which are well below what they should be.

2.2.4 Fertilization

Fertilization is the process in which fertilizer is applied to the lawns. Fertilizer is a combination of natural and synthetic materials, including nitrogen, phosphorus, and potassium compounds, spread on or worked into soil to increase its capacity to support plant growth. Fertilization at WPI occurs only twice a year due to budget constraints. Fertilizing properly should be done at least four times a year. The total budget for the fertilization program is approximately $4600[5]; however, most of that money is allocated

[4] E-Grounds IQP; 2004
[5] E-Grounds IQP; 2004

to other areas of the Grounds Services division because the budget for the entire division is not suitable.

2.2.5 Mulching

Mulch is a protective covering placed around plants to prevent the evaporation of moisture, the freezing of roots, and the growth of weeds. Mulch can also be in the form of small pieces of tree bark. Typically, mulching does not take up a large amount of time in terms of grounds maintenance at WPI.

2.2.6 Soil

The soil is maintained by taking pH levels of the various sections of the campus. Currently WPI Grounds Services measures forty-two separate locations around the campus. Every year the pH level is taken and measured. In order to maintain the proper pH levels, lime is added to raise the pH level to the proper acidity level. This is necessary for the grass to grow properly.

2.2.7 Disease and Insect Control

Disease and Insect Control has not been a real concern on the WPI campus. The only time this is done is during the summer season. Here the groundskeepers are instructed to check the lawn for abnormal amounts of insects. There are no maintenance tasks that included spraying plants or grass with insecticides, pesticides, or herbicides which would protect plants and grass from serious damage. If in fact disease or insects become an

issue, typically a chemical treatment is included within the fertilization, liming or seeding processes done on a seasonal basis.

2.3 Grounds Maintenance at WPI

The grounds maintenance team at WPI consists of 8 gardeners that maintain the upkeep five estates, eleven residential halls, nineteen academic buildings, and thirty peripheral properties that make up WPI's property. The organizational structure and chain of command starts at the top with Mr. John Miller, the Director of the Physical Plant. Mr. Miller heads all maintenance and upkeep activities at WPI, including both lawns and buildings. Reporting directly to Mr. Miller is Mr. Ronald Klocek, who serves as the Grounds Services Department Manager, and manages the gardeners. The team of seven full-time gardeners is down two members from its original nine members, as two team members had to be let go due to budget cuts and restraints.

Before the onset of the E-Grounds Project which began last year, an overall evaluation of the management and organizational structure of the Grounds Services Department had never occurred. As in any business or industry, periodic evaluations of the performance of the business team are essential to gaining knowledge about what needs to be improved in order to make the operation more successful. It became apparent that the Grounds Services Department was in need of a more organized and efficient way to assess themselves as well as organize their everyday affairs. It was for this reason the E-Grounds IQP came to exist.

See Appendix A for a full and detailed description of Grounds Maintenance at WPI.

2.4 E-Grounds at WPI

The E-Grounds IQP at WPI had its origin in terms B, C and D of 2004. Within the grounds maintenance department, it became evident that WPI needed a more detailed and better organized system for managing and maintaining the grounds of campus. Thus being a technical school, this managerial and organizational system should be driven through the use of modern technology and Geographic Information Systems (GIS). GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, for example, trees, plants, and flowerbeds identified according to their locations in the world. The system allows groundskeepers to investigate the layout, manage their resources, and effectively come up with a plan of action to maintain the grounds.[6]

The previous group was able to do a very effective job of setting the foundation of the E-Grounds project so that future groups could take it to the next level. A fantastic job was done in cataloguing every aspect of the physical campus, ranging from lawns and flowerbeds to hard surfaces and buildings.

[6] E-Grounds IQP; 2004

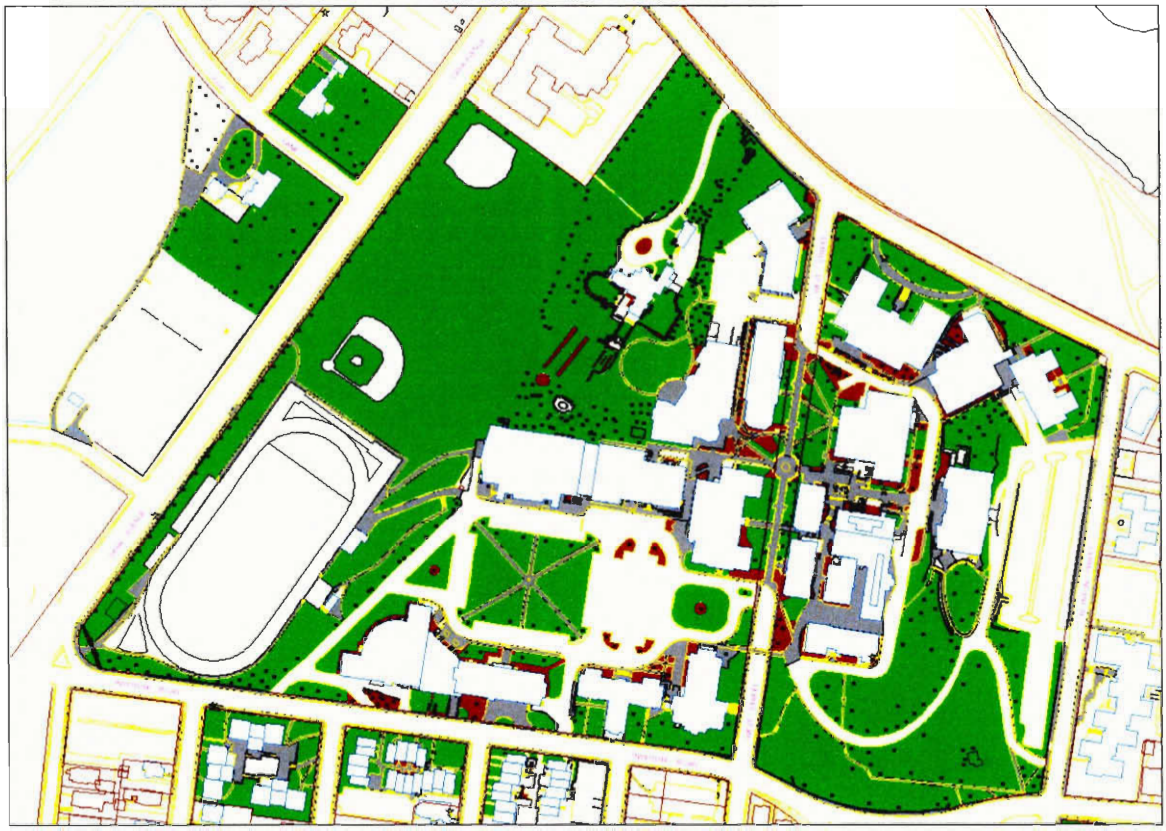

Figure 6: Catalogued Campus Map[7]

These aspects of campus were also linked to a Microsoft Access database which gave every piece of campus an ID code so that it could be easily defined and labeled for future analytical endeavors. Also, the notion of service levels were also introduced to the grounds maintenance team, which laid the framework for the development of desired levels of service and task frequencies as set forth by this project. Essentially, as stated, the previous work done by the E-Grounds IQP established the necessary information so that future groups could spend more time on analytical aspects of the project.

[7] E-Grounds IQP; 2004

3. Methodology

3.1 Mission Statement

To assist WPI's grounds maintenance staff in maintaining WPI's campus efficiently and effectively through the use of technology.

3.2 Problem Identification

At the onset of the E-grounds IQP, in 2004, it was established that the Plant Services Grounds Maintenance Department manages and maintains all aspects of WPI grounds on campus and for its peripheral properties. As society continues to move further and further along through the computerized age, processes that were once only thought to be manual endeavors have become more easily completed through the use of technology and computerization. The object of the E-Grounds project as a whole is to assist the Grounds Maintenance Department at WPI in reaching a point where their management and scheduling process becomes completely computerized, all the way from scheduling tasks to the amount of material needed when placing orders. The process of reaching this point is a long one with many steps required, and this particular IQP is the second stage in a series of steps required to reach the final destination.

Beginning to identify the purpose and goals of this project required the group to view this as an opportunity to take the next step. This next step could not be taken successfully

without a full understanding of the work that had been done previously and how it would assist the group in adding value to it. E-Grounds 2004 successfully catalogued the required physical information that the Grounds Maintenance team uses on a daily basis. Every lawn, hard surface and flowerbed was organized into Microsoft Access databases with names and square footage included. These databases were linked to a computerized mapping program, or GIS program, that allowed visuals of the campus and its aspects to be shown, to scale with the grounds maintenance information displayed in it. By doing so, the E-Grounds 2004 team put in place all the necessary information required to take the next step. The purpose of their project was to create a database system that included all the pertinent information regarding grounds maintenance at WPI that could be accessed very easily while making management decisions. The group successfully met their goal, setting the stage for work to be done on top of what they accomplished.

With all the necessary information in place, it was evident that the information was of no use to the grounds maintenance team without it being put to work for them. It became clear that the next step was to determine how the information could be used to improve grounds maintenance at WPI and to display the information working towards improvement. This project was viewed as an increase in the level of specificity, taking the foundation of information given to use from last year's project and building upon it to achieve some actual physical and statistical results.

3.3 Scope

The main objective of this project was to determine whether or not, with the available current resources, the WPI grounds maintenance team has the ability to maintain the grounds at the desired level of service. Through beginning to work on completing this objective and analyzing the steps required in achieving this goal, it became clear that the scope of the project had to become more specific as it was seemingly unfeasible to complete this task for every aspect of the grounds at WPI. The group chose to complete this objective on the lawns at WPI, as they compose the largest facet of the grounds at WPI, and would serve as a model for completing the same objective for both the flowerbeds and hard surfaces. The combination of these three components of the grounds would paint a complete picture of the ability to effectively maintain the grounds both with the current level of resources and potential levels of resources.

Through working with John Miller and Ron Klocek it was determined that a truly helpful objective and end result of this project would be to provide the answer to the questions: "Do we currently have the resources to achieve our desired level of service?;" "With out current resources what is our current level of service?;" and "What level of service can be reached with an increase in resources?." In respect to this case, the term resource is synonymous with man-hours and available employees. Answering these questions required an extensive evaluation, analysis and synthesis of every aspect of caring for the lawns on WPI's campus.

3.4 Level of Service

Before this extensive evaluation of the lawn care at WPI could take place however, a consistent and complete understanding of the term "Level of Service" was necessary for both the group members and participating members of the grounds maintenance team. The Plant Services Department at WPI follows protocol as set forth by the APPA (The Association of Higher Education Facilities). In terms of grounds maintenance, the APPA has published a booklet that establishes the standards for maintaining the grounds of any type of higher education facility. This booklet includes every possible piece of information fathomable regarding maintaining every aspect of a campus. For grounds maintenance it is highly detailed with specific tasks, frequency of performing tasks, how to perform them all the way down to preferred equipment types.

The APPA has established the term "Level of Service" which is basically a ranking or grade given assigned to a whole campus, or a specific lawn, which reflects the quality of upkeep given to that area. The Level of Service scale goes from Level 1 through Level 5 with Level 1 being the best and Level 5 being the worst. Level 1 is described as "state of the art maintenance" while level 5 is described at "minimum level maintenance." For our purposes, we established views of these levels of service as a level 1 being perfect maintenance and level 5 as almost a level of disservice. It is stated in the APPA booklet that "Associated with well-developed public areas, malls, government grounds, or college/university campuses, a level of attention 1 or 2 should be upheld." By this statement, WPI as a whole should fall into a Level 2 ranking. As it stands, WPI seems to have an average service level of 3, which is good, but not quite where it needs to be. It

should be kept in mind however that the ranking of Level 3 is an average for the entire campus, and thus some areas are Level 1 or Level 2; it is here where this is room for improvement, as increasing some of the lower service level areas could bring the campus average up to a level 2.

3.5 Matrices

Within the APPA booklet for grounds maintenance, sample maintenance schemes are given to assist in the planning of actual maintenance schemes at actual schools for the facilities planners who adhere to the APPA standards. These sample schemes display the proper tasks and frequency of these tasks to be undertaken to maintain lawns in an effective and efficient manner. Deciphering the information given in these sample schemes allowed us to produce sample task matrices displaying information regarding tasks, frequency of completion and man-hour calculations. (Table 1)

Table 1: Lawn Task Matrix

	A	B	C	D	E	F	G	H	I	J	K
1	**Lawn Care Matrix**	1000 Square feet									
2	**Cycle Length**	30 weeks									
3	**April 1-October 31**										
4											
5											
6		**Level 1 (min/wk)**		**Level 2 (min/wk)**		**Level 3 (min/wk)**		**Level 4 (min/wk)**		**Level 5 (min/wk)**	
7	**Maintenance Task**	**times/week/cycle**	**min/week**	**times/week/cycle**	**min/week**	**times/week/cycle**	**min/week**	**times/week/cycle**	**min/week**	**times/week/cycle**	**min/week**
8	**Mowing**	1.50	9.00	1.00	6.00	1.00	6.00	0.50	3.00	0.50	3.00
9	**Fertilizing**	0.13	0.39	0.07	0.21	0.07	0.21	0.03	0.09	0.00	0.00
10	**PTO Broadcast**	0.13	0.03	0.07	0.02	0.07	0.02	0.03	0.01	0.00	0.00
11	**Crabgrass Control**	0.07	1.05	0.03	0.45	0.03	0.45	0.00	0.00	0.00	0.00
12	**Weed Control**	0.13	1.04	0.07	0.56	0.07	0.56	0.03	0.24	0.00	0.00
13	**Sweep**	0.20	0.40	0.10	0.20	0.07	0.14	0.03	0.06	0.00	0.00
14	**Edge, Trim, Clean; Walks**	1.50	7.50	1.00	5.00	0.50	2.50	0.25	1.25	0.00	0.00
15	**Trim Raised Objects**	1.50	1.50	1.00	1.00	0.50	0.50	0.25	0.25	0.00	0.00
16	**Vacuum**	0.20	2.00	0.10	1.00	0.07	0.70	0.03	0.30	0.00	0.00
17	**Overseed**	0.07	2.10	0.03	0.90	0.03	0.90	0.00	0.00	0.00	0.00
18	**Aerate**	0.20	6.00	0.10	3.00	0.07	2.10	0.03	0.90	0.00	0.00
19											
20	Total min/week		31.01		18.34		14.08		6.10		3.00
21	Hours/week		0.52		0.31		0.23		0.10		0.05
22	Persons/day		0.09		0.05		0.04		0.02		0.01
23	Staffing level/week		0.02		0.01		0.01		0.00		0.00
24	Square feet/person/week		58045.79		98146.13		127840.91		295081.97		600000.00
25											
26											
27	**Activity Frequency**		**Adjustment Factor**		6 times/season		6/30=0.20				
28	1.5 times/week		1.50		5 times/season		5/30=0.17				
29	1 time/week		1.00		4 times/season		4/30=0.13				
30	biweekly		0.50		3 times/season		3/30=0.10				
31	monthly		0.25		2 times/season		2/30=0.07				
32					1 time/season		1/30=0.03				
33											

By creating these sample matrices from the information found in the APPA booklet, the group discovered how it would be able to go about gathering and synthesizing the information we needed to meet its objectives. Important adjustment factors and frequency values were also generated from these matrices. The matrices also gave a foundation of knowledge regarding how much resources are needed to maintain different levels of service. For example, from this sample matrix, it can be seen that one person can maintain approximately 58,000 square feet per week at a level of service one. Although there is sincere validity in these matrices, they were not designed specifically for WPI, but did show the group how to create specific maintenance schemes for WPI's campus.

3.6 Lawn Tasks

Working with Ron Klocek and discussing the given tasks from the sample matrices more in depth, we were able to combine the numerous tasks into 6 maintenance areas that would become the most important aspects of this project. For all types of lawns, the maintenance tasks developed were mowing, edging, seeding, fertilizing, liming and aerating. These tasks are performed on all types of lawns; however different lawn types may require a task to be performed more or less frequently. For the purposes of this project and for WPI's maintenance scheme, a 30 week active cycle is the time frame taken into consideration for these tasks. From April 1st through October 31st is the block of time that was chose to be taken into consideration, as this is the active growing season when lawn care is at its peak.

3.6.1 Mowing

Mowing is the most basic and fundamental of all maintenance tasks done on lawns, yet it is also the most important and often the most noticeable. Depending on the level of service, mowing should occur 1.5 times per week on level 1 areas, once per week for levels 2 and 3 areas, and once every 2 weeks for levels 4 and 5 areas. The grounds maintenance team at WPI makes use of 4 different kinds of lawn mowers, all 4 of which were taken into consideration and used in our analysis and creation of lawn care scheme. The 4 types of mowers are a 60 inch power mower, a 36 inch power mower, a 48 inch power mower, and a 21 inch manual mower. All of these lawnmowers are used throughout campus, on different lawn areas, depending on the type of lawn or particular level of service for that lawn.

3.6.2 Edging

Behind mowing, edging would be the second most noticeable facet of lawn maintenance, and as it would come to show, also the most time consuming. For the purposes of this project, edging encompasses all edging and trimming activity including weed whacking, manual trimming of small areas and sidewalk edges. For a level of service 1, edging would take place once every two weeks. For levels of service 2 and 3, edging occur once every 4 weeks and for levels of service 4 and 5, edging does not occur during the active season. Manual edging is the only practice used at WPI, as it brings with it the best looking results, despite the downfall of it being a far slower process than using heavy equipment or automated types of edging.

3.6.3 Seeding, Fertilizing, Liming

Seeding, Fertilizing and Liming fall into the category described as "Occasional Tasks." They do not occur on a weekly basis, but rather the frequency of their completion is spread out over the entire active cycle. In terms of fertilization, at a level of service 1, lawns would get fertilized 4 times throughout the active cycle, 2 times over the cycle for levels 2 and 3, and one time over the cycle for levels 4 and 5. For liming, each lawn receives the treatment once over the active cycle, regardless of level of service. For seeding, lawns at a level of service 1 get seeded twice a cycle, while all other levels of service correspond with only one seeding per cycle. All three of these tasks however are connected by the fact that they all use the same piece of equipment. WPI makes use of a walk behind Cyclone spreader, which spreads the treatment in a 15 foot radius as it is

pushed. The grounds maintenance team has a number of these machines, enough so that every member of the team could be using one at any particular time. These tasks do not tend to take up a majority of the available man-hours as they are occasional cyclic tasks rather than steady weekly maintenance tasks.

3.6.4 Aerating

Aerating is also considered an occasional task done over the active cycle. For lawns with levels of service 1-3, aeration takes place only once over the 30 week cycle, and for lawns with levels of service 4-5, aeration is not performed. Aeration is a very slow very process, which uses a very expensive piece of machinery, and at WPI this piece of machinery is a 24 inch, walk behind aerator. Part of the reason aerating does not take place on the same scale as liming, fertilizing or seeding is because of the amount of time it would take to do so. It would take time and cost a lot more money, and as seen through the eyes of the APPA, not as necessary as the other, cheaper and more time efficient tasks.

3.7 Databasing

All of the aforementioned information regarding level of service, maintenance tasks, frequencies and equipment was entered and organized into a large database encompassing a series of tables, queries and forms that are capable of synthesizing, manipulating and shaping the data to form conclusions and valuable information. The information held within this database, was also linked to MapInfo, the GIS (Geographic

Information System) which last year's project team successfully mapped out the WPI campus on.

The initial step which needed to be taken was to assign each lawn with a currently desired level of service. We got these current desired levels of service from Ron Klocek and entered them into a new table. This step was imperative and necessary as the first step, due to the fact that all frequencies of completion for each task are dependant upon the level of service for each lawn. Getting this information into the database built a strong foundation to build the rest of the database on.

Once each lawn was assigned a corresponding level of service, the next step was to tackle each lawn task individually, and generate as much information as possible regarding each task. Each task then had to be linked to its corresponding equipment which included the times it took for each piece of equipment to complete its designated task over a specific area of square footage. Once this information was in place, it became easy to link each lawn with a specific task and find out how long it would take to complete that task on that lawn one single time.

Once this was completed for each lawn and each task, the next step was to generate overall cycle times with frequencies based on individual levels of service for each lawn and task. After this step was completed, each lawn had six corresponding values representing the man-hours required to complete each task over the course of the 30 week cycle based on the level of service given to each lawn. The sum of these six values equals

the total number of man-hours required to maintain each lawn at the current desired level of service. Synthesizing and analyzing this data set is what would go to show the answers to the questions set forth by the project group and allow the project objectives to be met.

4. Results

4.1 Lawn Specific Service Levels

The first area in which a substantial result was reached was in the creation and determination of lawn specific service levels. Rather than assigning an overall level of service to the entire campus, it became evident that it would be more beneficial to assign levels of service to each specific lawn, which would enable a more realistic and achievable standard for maintenance. These specific levels of service were reached through working with Mr. Klocek, who took the time to view some of the MapInfo images created. Through analyzing the current amount of attention paid to different areas, as well as the importance of different areas based on administration needs and overall traffic, he was able to label a set of maps with desired service levels for each lawn, as well as the proper equipment that should be used while maintaining these areas.

Figure 7: Lawn Levels of Service

Adding these maps and included information into MapInfo, allows easy changes to be made to the overall management system with only a small change being made within the GIS program. For example, if for some reason the quad needs to be bumped up a level in service, then having the service level for individual lawns within the databases and mapping makes it easy to recalculate all of the necessary figures needed to maintain the area. By completely transforming the maintenance operation into a technology based system, these changes which would normally be daunting tasks become quite simple, and

the technology does the work for you. The removal of this human work process saves time and money and also increases the quality of service.

4.2 Overall Lawn Maintenance

With all the necessary information in place within the Access databases, results regarding every facet of maintaining the lawns were not hard to come by. The first piece of information that arose from the databases was an entire compilation of the time it takes to perform each task on each lawn, regardless of level of service but based on the proper equipment used to complete the task. No information such as this has ever existed within the grounds maintenance system, but now, armed with this information, the management knows exactly how long any task should take someone to complete, therefore, performance levels of employees can now be measured on both efficiency and quality, rather than simply how the area looks when it's done. This information exists in table L0)_Overall_lawn_mh, a relatively lengthy yet very important database within the electronic system.

The next pertinent information set that arose in regards to the maintenance of the lawns was the cyclic man-hours for each lawn, for their determined level of service. This piece of the electronic system delivers the information of how many hours will be spent each season, on a particular lawn, based on the proper equipment as well as the frequencies determined from the given level of service to that specific lawn.

4.2.1 Mowing

The most important aspect of maintaining the grounds of any campus at the highest level is mowing the lawns. Through utilizing the technology made available, along with the knowledge gained through research and investigation, mowing GIS maps were easily created. The first map that was created regarding mowing was the mowing equipment map, as the time it takes to mow each lawn is directly related to which piece of equipment is used to complete the task.

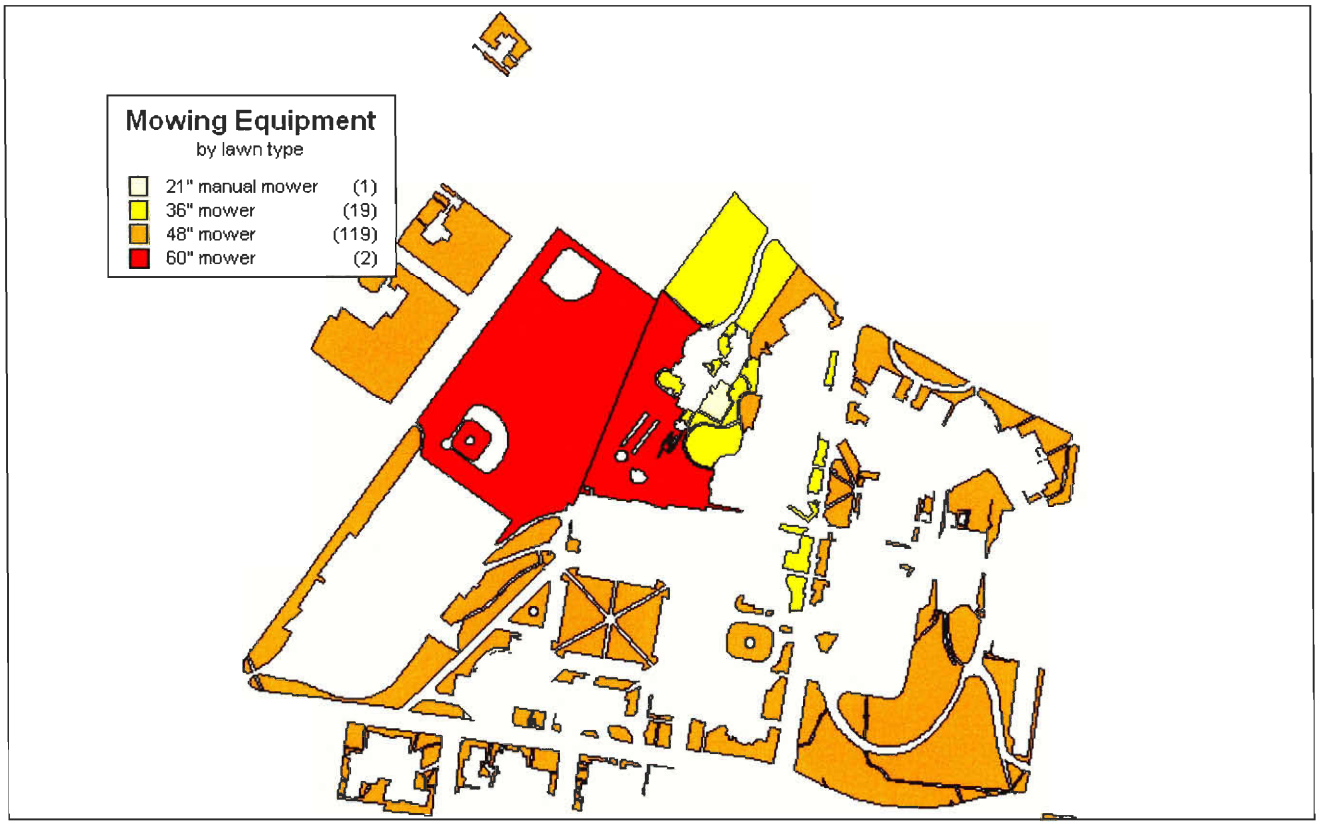

Figure 8: Mowing Equipment

Once the proper for each lawn had been defined, it became trivial in determining the amount of time it would take to complete mowing each lawn, as this value is simply a product of the size of each lawn and the size of each piece of equipment. What is fantastic about the GIS maps that are linked to the Microsoft Access Databases is that the values for mowing times could be recalculated within minutes if a piece of equipment broke or a new one purchased.

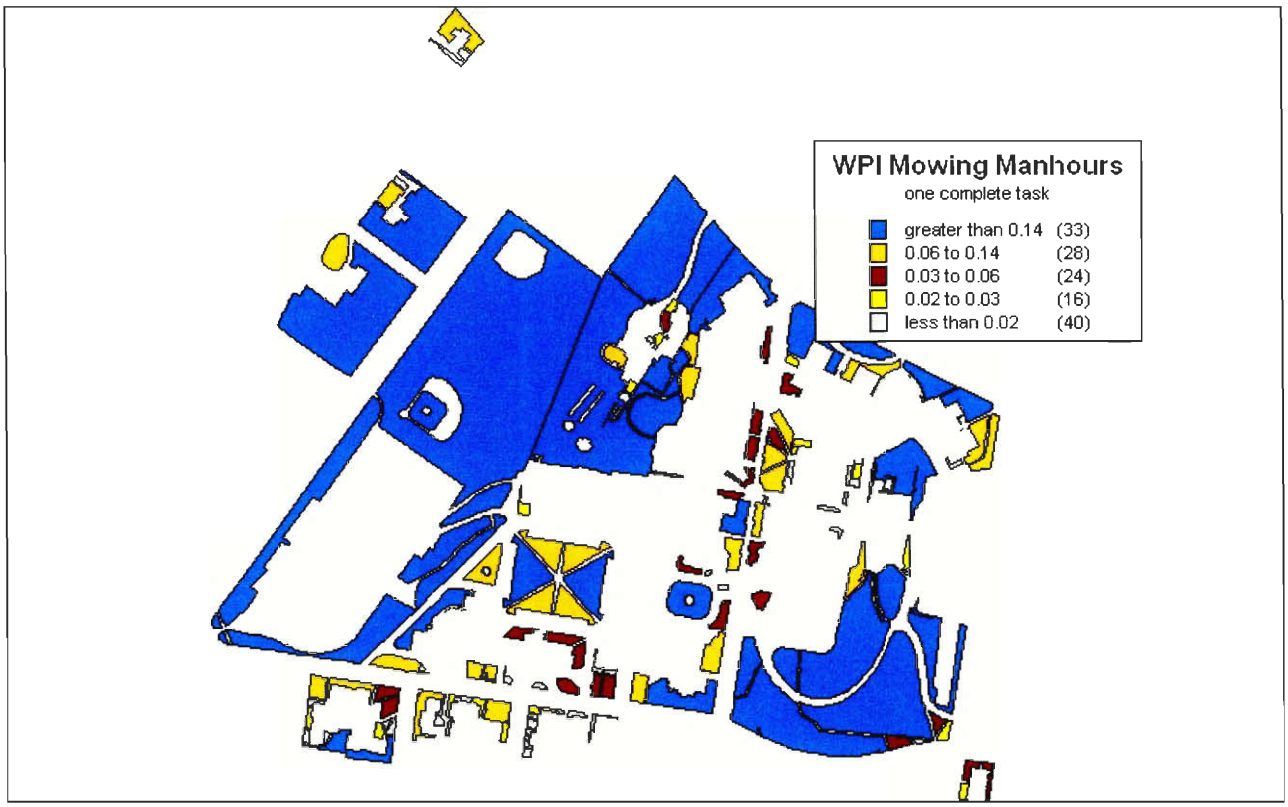

Figure 9: Mowing Man-hours

After completing the calculations and creation of the thematic map for mowing man-hours, it became evident that it would be more useful and easier to understand for the reader of the map if it was completed in minutes. The time in minutes would definitely

give whoever is reading the map a more realistic grasp as to the amount of time it takes to complete the task.

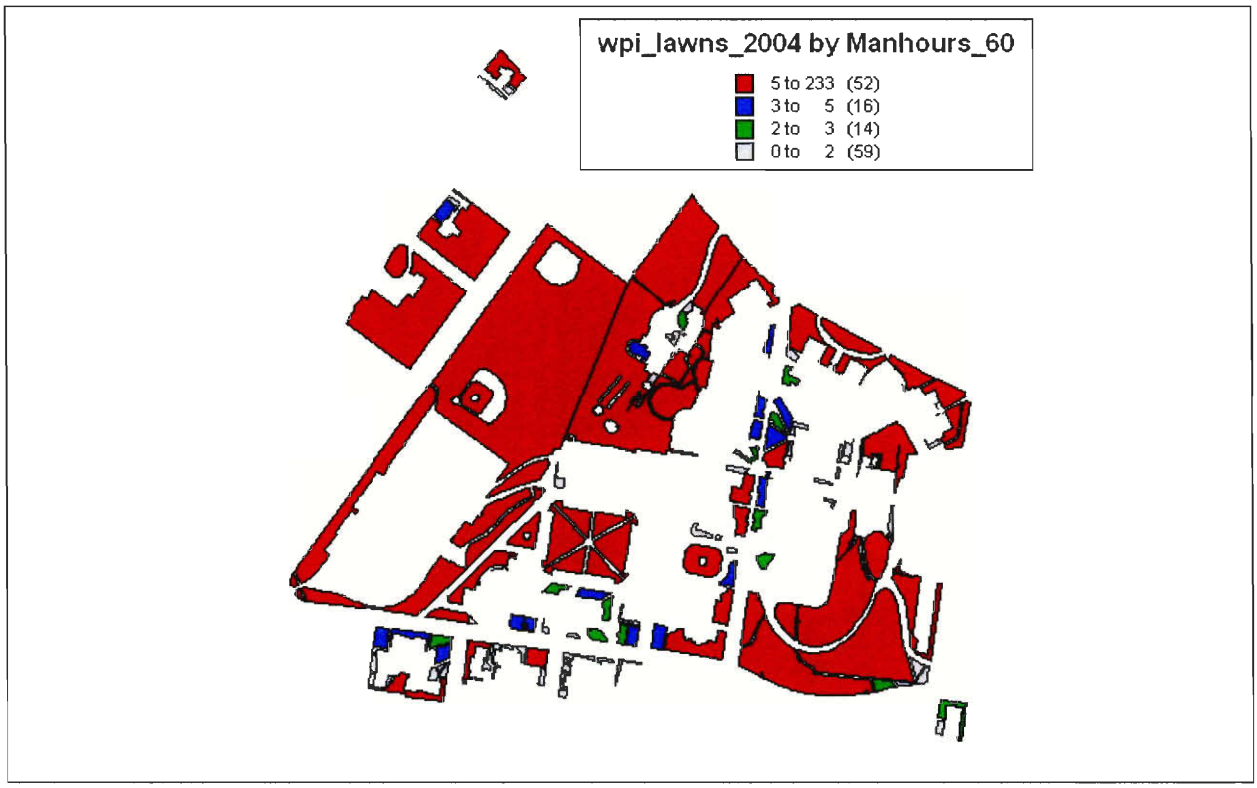

Figure 10: Mowing Minutes

4.2.2 Fertilizing, Liming & Seeding

For the tasks of fertilizing, liming and seeding, it became possible to combine the three value sets tabulated in the databases due to the fact that all three tasks are completed with the same type of equipment. Therefore, it would take the same amount of time to seed or fertilize the same lawn. Because this is true, only one GIS map needed to be created to display and represent the required man-hours necessary to complete these tasks.

Figure 11: Fertilizing, Liming, Seeding; Man-hours

As can easily be seen from the graphical display of the map, there exists a very large range of time values for the completion of these tasks on each lawn, however there is a very even distribution of the amount of lawns that exist in each time category on the map. Once again, any change in equipment, lawn size or any other piece of information pertaining to these tasks or how long it takes to complete them could be easily changed within the electronic system and brand new values could be determined within minutes making it very easy to determine the effects that any changes could have on overall lawn maintenance.

4.2.3 Edging

Figure 12: Edging Man-hours

Edging is the task that is responsible for the most hours in terms of overall lawn man-hours when taking into account all tasks. Again there is a very large range of values for times it takes to complete each lawn, yet again there is a very even distribution of lawns that take a very short time and lawns that take longer to complete. Since edging is often not able to occur due to time constraints, this value set is once again easily adjusted in any way, which can make changes very easy to perform.

4.2.4 Aerating

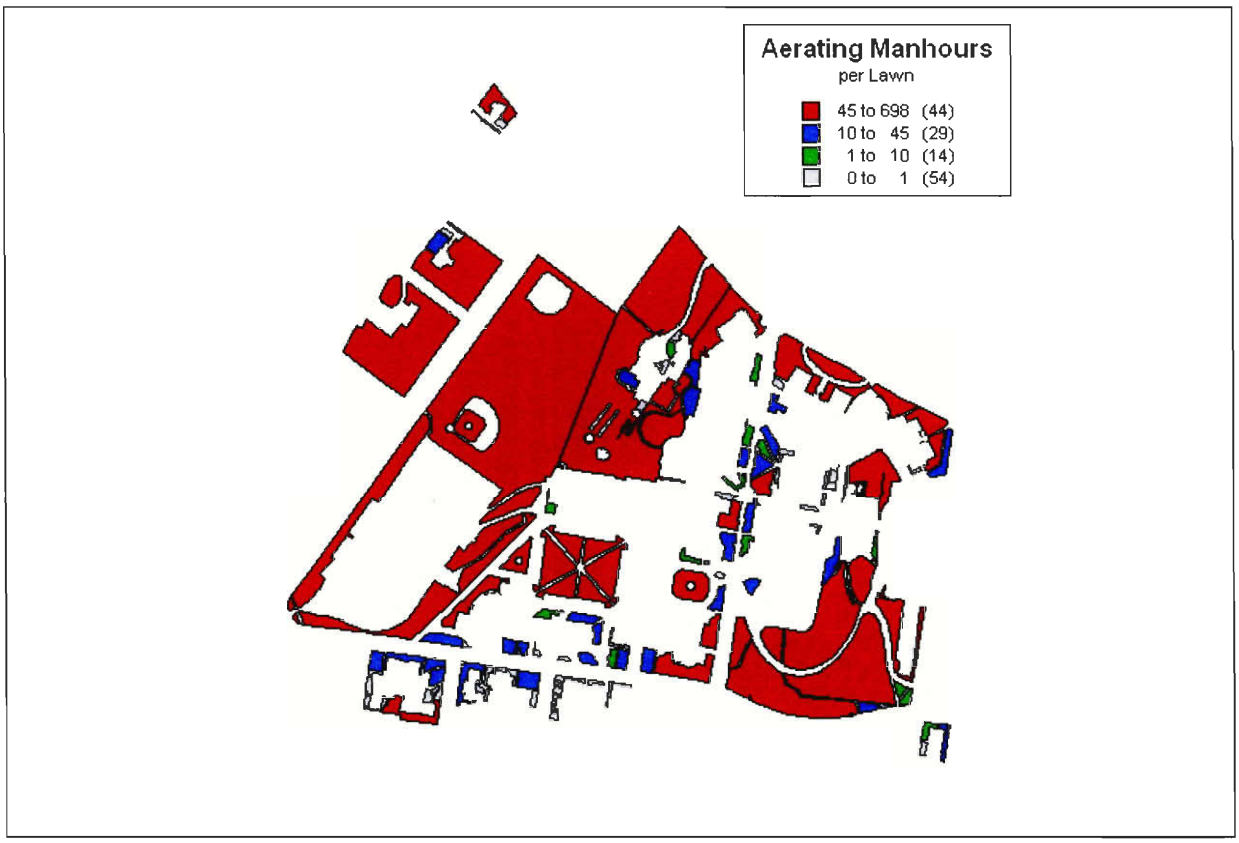

Figure 13: Aerating Man-hours

Although aerating is not completed on most of the lawns on campus, a GIS map was still created for completion purposes. Also, in the event that aerating became a task that became required on certain lawns, the information exists within the electronic system so information could be easily determined in terms of aerating any lawn on campus. Aeration is a very slow process, especially with the equipment currently being used as standard for aeration on campus, which is responsible for the very high values of man-hours in the map. It must be taken with a grain of salt however, because as previously stated, aeration does not occur on most lawns at WPI at all, however with this map, the proper information does exist should the situation arise that it is needed.

4.3 Seasonal Lawn Maintenance

Combining the previous results for each lawn maintenance task, coupled with information regarding level of service and seasonal frequencies based on those levels of service allowed the yielding of overall lawn maintenance figures for each lawn, over the course of a 30 week season. The values were first determined within the database which holds all the necessary information for completely maintaining each lawn on the campus of WPI, and then transferred into a GIS map which depicts the range of values for the man-hours required for each lawn's maintenance.

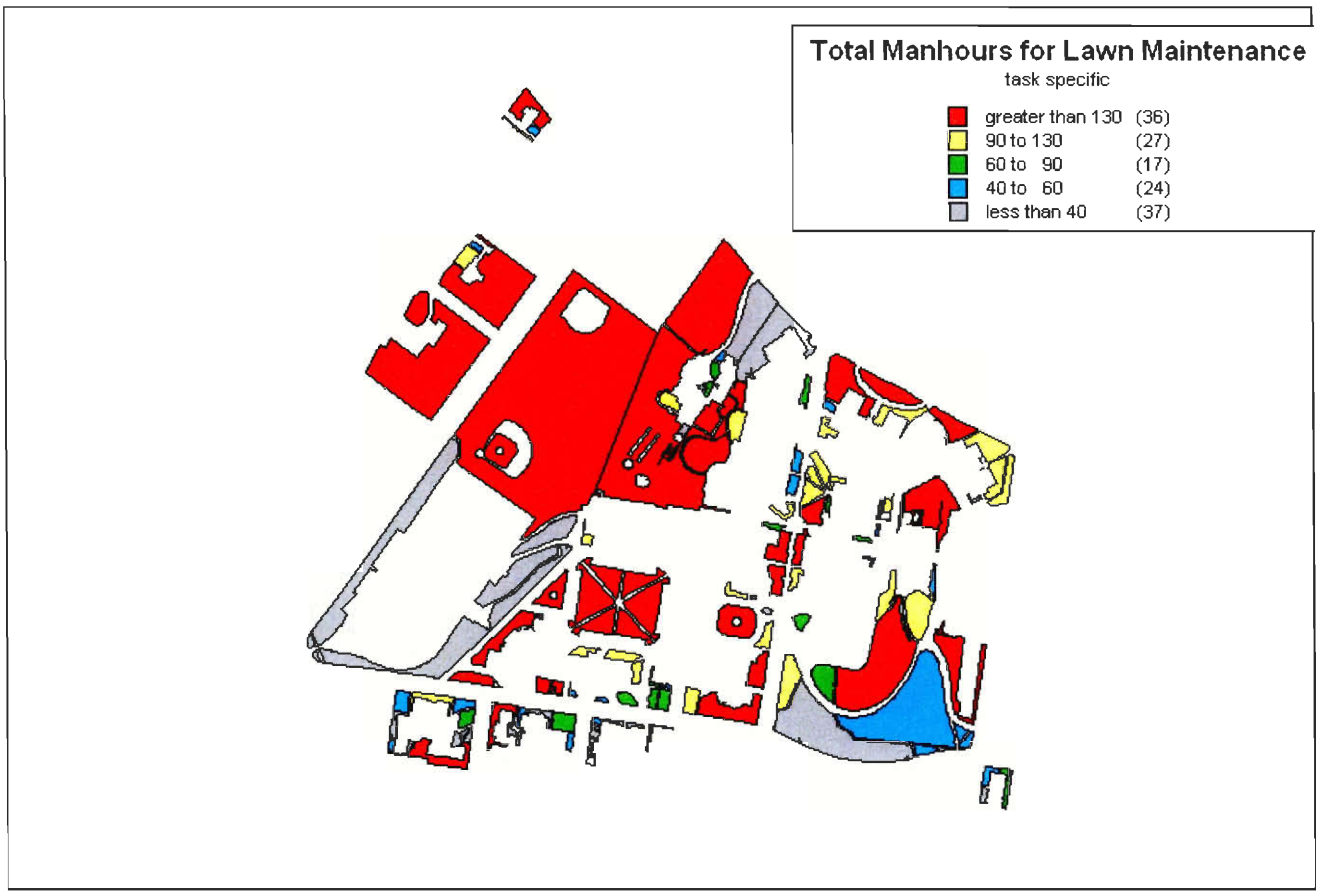

Figure 14: Seasonal Man-hours

This map and the values shown on it represent the total number of man-hours it takes to maintain each lawn over the course of the 30 week active season. Taken into account within these values are each lawn task singly completion time, multiplied by the number of times it must be completed in the season based on level of service, and then added all together. From this map it can clearly be seen where most of the time is spent by the grounds maintenance team, and perhaps some areas which may not see much attention at all. As with the other GIS maps that sum to create this particular one, this map can be easily changed with any alteration that is made to the grounds maintenance system. These values can be recalculated with the push of a few buttons, and a new information set created. This map truly gives a realistic view as to the amount of time it takes to maintain the lawns on the campus of WPI.

5. Analysis

The analysis of the project's data was a teamed effort with Mr. Klocek. He has the best idea as to exactly how long it takes to complete each task, and with his help, it became easy to determine whether or not the data produced held merit and seemed valid. It became evident through this analysis that the most important piece of information that could be determined through the synthesis of all the information was whether or not, with the resources currently available to them, the grounds maintenance team had the ability to maintain WPI's grounds at the levels of service which are desired.

Whether or not the grounds maintenance team at WPI possesses enough resources to keep up the campus at the desired levels of service was a relatively simple analysis to reach. A sum of all the available man-hours in a 30 week season had to be compared to the sum of each lawn's seasonal maintenance hours.

- Total man-hours required to maintain WPI's Lawns based on the desired levels of service: 16,571.24
  - 7200 available hours, less than half the required time
  - Calculated man-hours figured to be on the high end
  - Desired levels of service are clearly unattainable with current resources

Figure 15: Analysis PowerPoint Slide

Clearly, within the initial analysis, a huge discrepancy existed between the available man-hours to the grounds maintenance team, and the amount of time it would take to complete lawn care for the entire campus at the desired levels of service.

Through further analysis however, and working with Mr. John Miller, it became evident that an error could exist within an initial condition regarding the amount of time it takes to manually edge a piece of land, which would skew the results either way up or way down in terms of man-hours for edging. Through discussion, it was decided that the total edging hours for the entire campus, was on the order of 10 times too large, as some areas are not edged manually and some not at all. This value was determined through working with Mr. John Miller and Mr. Klocek. A Microsoft Excel file was created to assist in the analysis of how this error affected the overall outcome of the numbers. This file is available in Appendix C.

Through this excel file and further analysis, it was determined that to maintain the lawns of WPI's campus at the current desired levels of service, would take approximately 5000 hours. This value is on the order of 2000 hours less than the available man-hours the grounds maintenance team has available to them. Thus, if the grounds maintenance team had no other responsibilities to take care of, then the lawns could be maintained at the desired service levels, perhaps even at higher service levels. It must be taken into consideration however, that the 5000 hours it was determined it takes to maintain, does not even consider the maintenance of flowerbeds, trees or anything else.

6. Recommendations

The major recommendation that could be made from this project would be for the addition of resources to be added during the 30 week active season where lawn maintenance is prevalent. As it stands presently, there is no way that it is feasible to maintain the campus of WPI at the desired level of service within the 30 week active season.

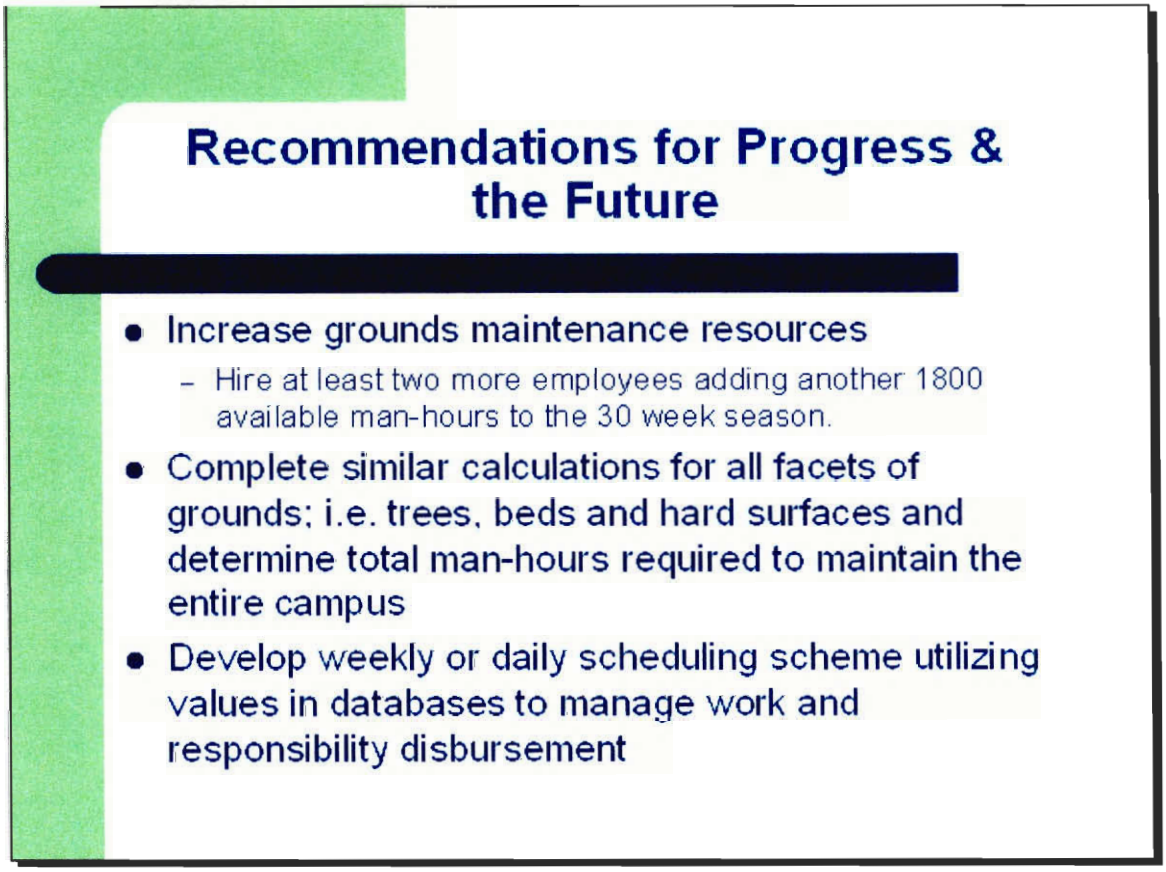

Figure 16: Recommendations PowerPoint Slide

Also, a similar version of this IQP should be completed for every other aspect of campus grounds maintenance in order to determine the total man-hours it would take to maintain the entire campus of WPI. With this complete, a total picture could be painted which

portrays whether or not enough resources are available to the grounds maintenance team to effectively do their job.

Similarly, once this total calculation could be completed, a weekly or daily scheduling scheme could be created which utilizes the man-hours and frequency values presented in the managerial databases to manage work and disburse responsibility. This scheme could also be used as measuring devices and evaluations for the employees working for the grounds maintenance team.

7. Summary

Initially, a complete review and understanding of last year's E-Grounds IQP took place. This laid the foundation for what needed to be done as the next step in E-Grounds Maintenance. The methodology then describes the steps taken to complete this project in a methodical fashion. Once the steps taken to complete this project were described, the results arrived at were displayed with GIS maps and Microsoft Access databases. The analysis then went on to describe what pertinent information can be taken from this project, as well as discrepancies within the project addressed. Recommendations for progress could then be taken to continue to improve the grounds maintenance effort at WPI. It is clear that WPI Plant Services can greatly benefit from this project and further projects expanding on our results and analysis.

Appendix A: E-Grounds 2004; Background

2. BACKGROUND

2.1 Grounds Maintenance in General

Employment[8]

Grounds maintenance workers held about 1.1 million jobs in 2002 in the US. Employment was distributed as follows:

Table 2.1: U.S. Employment

Landscaping and grounds keeping workers	894,000
First-line supervisors/managers of landscaping, lawn service, and grounds keeping workers	159,000
Tree trimmers and pruners	52,000
Pesticide handlers, sprayers, and applicators, vegetation	27,000

About 42 percent of wage and salary workers in grounds maintenance were employed in companies providing landscape and horticultural services. Others worked for firms operating and building real estate, amusement and recreation facilities such as golf courses and racetracks, and retail nurseries and garden stores. Some were employed by local governments, installing and maintaining landscaping for parks, schools, hospitals, and other public facilities.

More than 1 out of every 6 grounds maintenance workers were self-employed, providing landscape maintenance directly to customers on a contract basis. About 1 of every 7 worked part time; many of these were of school age.

[8] Grounds Maintenance Workers, http://www.bls.gov/oco/ocos172.htm

Earnings[9]

Median hourly earnings in 2000 of grounds maintenance workers were as follows:

Table 2.2: U.S. Hourly Earnings

First-line supervisors/managers of landscaping, lawn service, and grounds keeping workers	$14.70
Tree trimmers and pruners	11.41
Pesticide handlers, sprayers, and applicators, vegetation	11.11
Landscaping and grounds keeping workers	8.80

The WPI hourly wages for its employees as of 2004 are as follows:

Table 2.3: WPI Hourly Earnings[10]

Groundskeepers' Helpers	$15.00
Groundskeepers	16.15
Gardener 2	16.75
Gardener 1	17.35
Maintenance Mechanic/Groundskeeper	18.94

In comparison to the average hourly wages in 2000, the WPI grounds crew currently is paid more than average for their line of work. However, the WPI crew performs many more tasks and is asked upon by management to be responsible for more activities then most landscaping workers.

2.2 Level of Attention

The amount of work that can be done at a certain location depends upon one thing, money. With money, the staff number and supplies are accounted for and basically

[9] Grounds Maintenance Workers, http://www.bls.gov/oco/ocos172.htm
[10] Klocek, Ron. Interview with Ron Klocek. Recorded by T.J. McLaughlin. April 1, 2004.

any project can get done. Plant Services here at WPI has a limited budget to work with in order to keep the grounds presentable. There are certain levels of attention discussed in the APPA (The Association of Higher Education Facilities) booklet; levels 1 through 5 with 1 being a state-of-the-art maintenance and 5 being minimal-level maintenance. Associated with well-developed public areas, malls, government grounds, or college/university campuses, a level of attention 1 or 2 should be upheld. WPI seems to have an average level of attention of 3, but also including some aspects covered in levels 1 or 2. Some specific areas which need more attention due to high traffic areas, are Kaven Hall, Boynton Hill, Higgins House, the four corners of the campus, and any entrance into campus. The following describes the type of area that should be maintained and the tasks associated with that maintenance at level 2 which could be incorporated across campus.

2.3 Level 2 [11]

Turf Care

Grass cut once every five working days. Aeration as required but not less than two times per year. Reseeding or sodding when bare spots are present. Weed control practiced when weeds present a visible problem or when weeds represent 5 percent of the turf surface. Some pre-emergent products may be used at this level.

Fertilizer

Adequate fertilizer level to ensure that all plant materials are healthy and growing vigorously. Amounts depend on species, length of growing season, soils, and rainfall. Rates should correspond to at least the lowest recommended rates. Distribution should

[11] APPA, Operational Guidelines for Grounds Maintenance. United States of America, APPA, NRPA, and PGMS, 2001

ensure an even supply of nutrients for the entire year. Nitrogen, phosphorus, and potassium percentages should follow local recommendations. Trees, shrubs, and flowers should receive fertilizer levels to ensure optimum growth.

Irrigation

Sprinkler irrigation—electric automatic commonly used. Some manual systems could be considered adequate under plentiful rainfall circumstances and with adequate staffing. Frequency of use follows rainfall, temperature, season length, and demands of plant material.

Litter Control

Minimum of once per day, five days per week. Offsite movement of trash depends on size of containers and use by the public. High use may dictate daily or more frequent cleaning.

Pruning

Usually done at least once per season unless species planted dictate more frequent attention. Sculpted hedges or high-growth species may dictate a more frequent requirement than most trees and shrubs in natural-growth plantings.

Disease and Insect Control

Usually done when disease or insects are inflicting noticeable damage, are reducing vigor of plant material, or could be considered a bother to the public. Some preventive measures may be used, such as systemic chemical treatments. Cultural prevention of disease problems can reduce time spent in this category. Some minor problems may be tolerated at this level.

Snow Removal

Snow removed by noon the day following snowfall. Gravel or snowmelt may be used to reduce ice accumulation.

Surfaces

Should be cleaned, repaired, repainted, or replaced when their appearances have noticeably deteriorated.

Repairs

Should be done whenever safety, function, or appearance is in question

Inspections

Inspection should be conducted by some staff member at least once a day when regular staff is scheduled.

Floral Plantings

Normally, no more complex than two rotations of bloom per year. Care cycle is usually at least once per week, but watering may be more frequent. Health and vigor dictate cycle of fertilization and disease control. Beds essentially kept weed free.

Mulching

Mulches used in gardens suppress weeds, reduce soil erosion, modify the soil temperatures, cooler in the summer, and warmer in the winter, and conserve soil moisture. Yard waste compost makes ideal mulch for annual and perennial gardens. All that needs to be done is to apply a three to six inch layer of compost around the base of the plant. Periodically throughout the summer, you may need to add more compost over the old layers to maintain the benefits of the mulch.12

Soil pH

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[12] Ginsburg, Janet. The City of Chicago Guide to Urban Tree Care. Chicago, IL, City of Chicago Department of Environment, 1994.

It is generally easier to make soils more alkaline than it is to make them more acid. Because different soil types react in different ways to the application of lime you will have to add more lime to clay soils and peaty soils than you will in sandy soils to achieve

the same result.

To increase your pH by 1.0 point and make your soil more alkaline.

Add 4 ounces of hydrated lime per square yard in sandy soils

Add 8 ounces of hydrated lime per square yard in loamy soils

Add 12 ounces of hydrated lime per square yard in clay soils

Add 25 ounces of hydrated lime per square yard in peaty soils

If your soil needs to be more acidic, sulfur may be used to lower the pH if it is available. To reduce the soil pH by 1.0 point, mix in 1.2 oz of ground rock sulfur per square yard if the soil is sandy, or 3.6 oz per square yard for all other soils. The sulfur should be thoroughly mixed into the soil before planting. Sawdust, composted leaves, wood chips, cottonseed meal, leaf mold and especially peat moss, will lower the soil pH.13

2.4 Current Maintenance at WPI

Management14

The manager of the grounds, Mr. Ronald Klocek, heads the current maintenance system at WPI. His official title is Manager of Grounds and Properties. Mr. Klocek reports directly to the Associate Vice President for Business Affairs and the Director of the Physical Plant at WPI. The Associate Vice President for Business Affairs is Stephen J. Hebert. The Director of the Physical Plant at WPI, who is also the Liaison to this

[13] Crockett, James Underwood. Flowering Shrubs. New York: Time Life Books, 1972.
[14] Klocek, Ronald. "Manager of Grounds and Properties Position Description." 2000.

project, is John E. Miller. In Mr. Klocek's position description, it states that the basic function of his job is to "manage the maintenance of all campus grounds and properties peripheral to the campus." Meaning anything to do with the maintenance of WPI campus grounds and peripherals is his responsibility.

In order to become the Manager of Grounds and Properties at WPI, there are some requirements or prerequisites entailed. One must have an Associate Degree in horticulture or a related field desirable. One must also have six to ten years' experience in ground maintenance, with a minimum of three to five years in a supervisory role. Licenses and certifications related to his position are expected as well.

Mr. Klocek has many duties and responsibilities under his job description. He supervises the maintenance of all grounds, athletic fields, and on-site facilities on both the main campus and peripheral properties owned by WPI. He must collaborate with others, usually Mr. John Miller, to hire, and train personnel within his division of Plant Services. When a new project is undertaken to modernize, upgrade or maintain the existing campus grounds and/or peripheral properties he is in charge of managing the endeavor. He is also in charge of acquiring and maintaining new supplies needed to fulfill each operation. Periodically he inspects the current facilities in order to establish a need for maintenance and repair. The records and operations of all Plant Services vehicles are under his supervision. He is to cooperate with Mr. Miller and decide on the maintenance and operation of the peripheral properties on a basis of priority levels. He is responsible for campus functions, i.e. setting up, taking down, and moving of furniture. When required, he shall act as primary negotiator in union contract discussions. When it snows, he is responsible for campus snow removal and the salting of icy walkways.

Related to this, he is on-call twenty-four hours for campus emergencies that may arise. He is directly responsible for any expenditure over and above the proposed $800,000 budget. On top of all of these responsibilities he directs nine semi-skilled non-exempt union employees and up to ten student employees. He may however delegate authority to any of the employees to help fulfill his job requirements.

Employees[15]

The employees all belong to a labor union in order to protect their rights and to be able to have their opinions heard amongst the management of the university. The name of the labor union the nine employees belong to is the Service Employee International Union Local 615. Ronald Klocek himself does not currently belong to any labor union; however he represents the employees' voice in that union. Currently there are six gardeners, two groundskeepers and one Groundskeeper/Maintenance Mechanic that specializes in maintenance and fixing equipment around the campus. The six gardeners are divided into two types of gardeners, Gardener I and Gardener II. Gardener I have taken four college level courses in grounds maintenance and operate under a pesticide license. Gardener II has taken only two college level courses in grounds maintenance. (See Appendix B for Organizational Chart)

The two Groundskeepers are George R. Desmarais and Stephen J. Pajka. Donald W. Peterson, John D. Stoever, and Bruce D. Worthington are all Gardener I's. Thomas F. Barter, Thomas H. Bullens, and Robert M. Tupper, Jr. are all Gardener II's. The employee in charge of maintenance is Glen Whitcomb. Whitcomb is also responsible for grounds keeping when there is no maintenance to perform. Mr. Klocek is held directly responsible for the supervision of all nine of these employees. (See Appendix H for Job

[15] Klocek, Ronald. "Position Descriptions." 2000.

Descriptions and Qualifications for Gardener I, II, Maintenance Mechanic, and Groundskeeper)

Turf/Lawn Care16

There are three separate programs that the groundskeepers follow when maintaining the lawns and turf at WPI. In the spring, they go around and first remove any branches, twigs, papers, stones and any other debris that may have accumulated over the winter season. Next they remove all sand that accumulated over the winter from sanding the walkways and streets from the curb side lawn area. Then they go around and look for any ruts or large holes in the ground and they repair them by adding soil and leveling off the land. After leveling the land, they go around and look for any thatch, or dead lawn. When there is any thatch, they first remove the dead area and then level it off with fresh soil. When necessary they spot and slice seed in places where the dead lawn has been removed and the ruts have been replaced with new soil.

The next step in the spring process is to aerate the lawns in preparation for seeding and fertilization. Once the lawn regions are aerated, seeding begins. Seeding is necessary to replace and rejuvenate all the grass that has died from a snowy winter. Subsequent to seeding, fertilization takes place. The fertilization process is somewhat complicated and will be talked about in another section. Lime, or calcium oxide, is then put on the grass areas in order to balance out the acidity in the soil and increase the pH level. After all preparation for the lawn is complete, the mowers are checked for functionality and inspected to ensure proper operation. The lawns are then cut to a height of two and half to three inches.

[16] Klocek, Ronald. "Lawn Maintenance (Spring, Summer, Fall)" 2000.

Depending on the area, most of this takes about a week for each zone to complete by each worker(s). As Mr. Klocek explained in the interview, he estimated a total of one hundred and twenty-eight hours to complete the mowing of all the lawns WPI is responsible for. The largest zone is the peripheral properties, taking up to forty-eight hours to complete.17

During the summer, like the spring, all braches, twigs, papers, stones, and any other debris accumulated are removed from the lawns. Prior to mowing the lawn mowers are inspected to make sure they are operating properly. The lawns are cut to a height of two and half to three inches. Approximately one inch of water is added to the lawns per week depending on rainfall and other circumstances. The lawns are checked for substantial amounts of insects. Once a summer the lawns are again aerated and fertilized. According to Mr. Klocek, pesticide and insecticide applications do not exist in the normal maintenance activities.18

Again, during the fall, branches, twigs, papers, stones, any other accumulated debris is picked up from the lawns. In the fall, the leaves begin to fall off the trees, which require raking and removing from the campus. Prior to mowing the machines are checked for proper operation and again the lawns are mowed to approximately two and a half to three inches. Again, the lawns are aerated and fertilized. To reach the proper pH level the lime is added to the soil.

In all seasons, the lawn is mowed accordingly. During certain weeks, rainfall may be heavier than others, requiring the lawn to be mowed sooner than usual. After meeting with Mr. Klocek, he described that the activities and maintenance tasks that have

[17] Klocek, Ron. Interview with Ron Klocek. Recorded by T.J. McLaughlin. April 1, 2004.
[18] Klocek, Ron. Interview with Ron Klocek. Recorded by T.J. McLaughlin. April 1, 2004.

been described are not usually completed to their fullest. The biggest reason behind this is the budget, which is well below what it should be. (Maintenance Schedules found in Appendix G)

Flowerbed Maintenance & Planting19

Bed maintenance occurs in all seasons, but the actual planting occurs in the summer and fall seasons. In the springtime, Gardener's begin by raking out all the debris in the flowerbeds and cut back all the flowers that have grown to unnatural shapes. All the dead wood is cut from the shrubbery along with any weeds that have sprouted up. The beds are then edged for a natural clean look. After being cleaned and edged, the flowerbeds are then fertilized and fresh mulch is added to the flowerbed. Watering takes place through irrigation when available, yet manual watering takes place in most flowerbeds.

The summer process is similar to the springtime, watering, weeding, and cutting back any dead plant life where necessary. Plants are checked for any insect damage that occurred during the change of seasons. The mulch is fluffed to look presentable. In the summer time annuals and perennials are planted in the beds where desired along with the replacement of any dead shrubs. During the fall season the same maintenance occurs, however new plant bulbs and perennials are planted for the new season. During the past six years, approximately 20,000 perennial bulbs have been planted.20 All dead plant life is removed and the flower beds are prepared for the winter season.

The bed maintenance usually takes approximately a week to complete. As explained by Mr. Klocek, the crew works on beds in the spare time, while walking

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[19]Klocek, Ronald. "Bed Maintenance (Spring, Summer, Fall)" 2000.
[20] Miller, John. "WPI Alumni: The Bridge" <http://www.wpi.edu/Admin/Alumni/Bridge/0703.html> July 2003.

around the campus performing everyday tasks, they weed the gardens when necessary. As far as scheduling set dates on when each garden is to be maintenanced or weeded, he explained that no such schedule exists. There is no distinct process or set times for each garden or activity.21 (Maintenance Activities found in Appendix G)

The flowerbeds around Higgins House receive the best attention. They are subcontracted to a local company, Perennial Planning, which on a weekly basis comes and performs the basic maintenance tasks to all of the flowerbeds surrounding the Higgins House. Since the Higgins House is one of the most prestigious aspects of the WPI campus, it must receive the best attention. Perennial Planning also is responsible for the President's house located on 1 Drury Lane, and the Vice President's house located on 15 Regent Street. Again these properties are highly respected by WPI, therefore receiving the best care.22

Fertilization23

Fertilization is the process in which fertilizer is applied to the lawns and flowerbeds. Fertilizer is a combination of natural and synthetic materials, including manure and nitrogen, phosphorus, and potassium compounds, spread on or worked into soil to increase its capacity to support plant growth. The fertilization program at WPI, as Mr. Klocek has explained, does not exactly happen the way that it should. The lawn is supposed to be fertilized in the springtime, during the summer, and before the snow begins to fall in the fall. However, the budget allows for the fertilization to take place a maximum of two times a year. The total budget for the fertilization program is

[21] Klocek, Ron. Interview with Ron Klocek. Recorded by T.J. McLaughlin. April 1, 2004.
[22] Klocek, Ron. Interview with Ron Klocek. Recorded by T.J. McLaughlin. April 1, 2004.
[23] Klocek, Ronald. "Fertilization Program." 2000.

approximately $4600; however, most of that money is allocated to other areas of the Grounds Services division because the budget for the entire division is not suitable.

Currently there are forty different zones that need fertilization, each having a fixed cost per square foot of area needed to be fertilized. The zones are broken into two classifications: Classification 1 – high maintenance areas, and Classification 2 – low maintenance areas. The high maintenance areas include Morgan Hall, the Quad, the Beech tree rotary, Higgins house, Atwater Kent, Kaven Hall, the area on Institute road, and the West Street area. These areas are all high maintenance areas because they are areas that are most seen by visitors and potential students. Therefore, these areas need to have a higher per square foot cost, since more fertilization is necessary. The high maintenance areas have a cost approximately three times that of a low maintenance area. The complete chart of all of the fertilization areas can be seen in Appendix C.

The high maintenance areas are supposed to be fertilized six times a year, during April, May, July, August, and October. The low maintenance areas are only fertilized twice a year, once in April and once in September. The high maintenance areas are fertilized in April to control remerging crab grass. In May, Confront Fertilizer with weed control is used to stop the growth of unnecessary weeds. In the month of July, the lawns are treated with Merit Preventive® grub control. These special fertilizers and care are reasons why the cost for the high maintenance area is more than the low maintenance areas. However, both times the low maintenance areas are fertilized they use special types of fertilizers. In the April fertilization application, the crews use fertilizer with Dimension® additives. In the September fertilization, application groundskeepers use fertilizer with Confront® additives.

Mulching[24]

Mulching is the process of covering an area of land with mulch. Mulch is a protective covering, usually of organic matter such as leaves, straw, or peat, placed around plants to prevent the evaporation of moisture, the freezing of roots, and the growth of weeds. Mulch can also be in the form of small pieces of tree bark. WPI currently uses mulch in all of the flowerbeds around the campus and on its multiple peripheral properties. All beds are raked, edged and fertilized annually in the current mulching plan. However, each area of land that needs mulch has a separate plan for mulching and when each bed gets new mulch. WPI Grounds Services use approximately three hundred cubic yards of mulch each year.25 Each area is on a different cycle and can be seen in Appendix D.

Each spring the gardeners are instructed to mulch the flowerbeds around campus after all debris is cleared out, flowers and shrubs are cut back, and all the beds are edged and fertilized. Then in the summer time, they are instructed to fluff up the mulch around the flowerbeds to make it look attractive. The beds that are most attractive and have the most appeal to visitors are the beds that get the most attention and care. For example, the quad and the West Street area get the most attention since students, visitors and potential students see these areas daily. The warm campus atmosphere is enhanced through proper mulching.

Irrigation[26]

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[24] Klocek, Ronald. "Mulching Plan" 2000.
[25] Miller, John. "WPI Alumni: The Bridge" <http://www.wpi.edu/Admin/Alumni/Bridge/0703.html> July 2003.
[26] Klocek, Ronald. "Interview with Ronald Klocek." Recorded by T.J. McLaughlin. December 11, 2003

The maintenance of plant life is impossible without the presence of water. The most efficient and effective way to water plant life is through an irrigation system. Through proper water management and irrigation, water and soil conservation is possible. In most facilities and universities, an elaborate automatic irrigation system is present. Irrigation systems are essential to efficient grounds maintenance. However, currently at WPI, there are only four automatic irrigation systems on the main campus.

Currently an irrigation system waters the rotary at the West Street entrance to WPI. This systems main function is to keep the Beech tree, its roots, and the grass covering the rotary constantly watered. Another irrigation system is located around the campus center area. The main function of this system is to keep the flowerbeds located in and around the walkways of the campus center constantly watered. The third irrigation system on campus is located on the walkway known as West Street. This area is defined as the walkway from Olin Hall, located on the corner of Salisbury Street and a private entrance to WPI, to Stratton Hall, located at the West Street entrance to WPI. The main function of this system is to keep the flowerbeds and small grass areas constantly wet. The fourth and final system is located on the Athletic fields. The system is brand new and was just installed over the 2003 summer. This irrigation system's main function is to keep both the softball and baseball fields watered during the green season.

These systems are currently in place not only to keep the area watered, but also to make it more efficient for the Grounds Services department at WPI. The current maintenance process at WPI does not allow for time for each gardener to sit for hours and manually water the flowerbeds and lawns around campus. This process would take

weeks and WPI does not have the money to implement this manual process. Therefore, automatic irrigation systems are necessary in every area that needs constant water.

The irrigation systems are very expensive to be installed. The estimated cost of the athletic field irrigation system (seen in Appendix J), was approximately $30,000. The cost of the Beech Tree system was approximately $4500. The two other systems, both very large, were the West Street system with an estimated cost of $30,000, and the Campus Center system, estimated at $25,000. Mr. Klocek explained that each year he has someone come and service the systems in the spring to start it up and in the fall to blow the lines out and shut them down. He explained that for each season the estimated cost to maintain the systems in $300 per season.27

In comparison to an irrigation system, the estimated cost of manually watering these areas would be phenomenal. In order to manually water each area, the set up and take down of the sprinklers and hoses would take an hour at least each time. On top of that periodically throughout the day the sprinklers would need to be moved, in order to cover the entire area that an irrigation system would account for. Granted the irrigation systems are very expensive, the system is a fixed cost and is incurred only once. To manually water the lawns and beds, the labor and water costs would begin to add up substantially after some years. In conclusion the irrigation systems are more cost effective.28

The current systems are in place at the various locations because they are the areas of campus most frequently seen by visitors and people from admissions tours. The area around the campus center is most seen by visitors and potential students taking tours

[27] Klocek, Ron. Interview with Ron Klocek. Recorded by T.J. McLaughlin. April 1, 2004.
[28] Idem.

around the campus. The same philosophy is behind the West Street walkway. These areas are irrigated currently because of the attractiveness and beauty the campus needs to have in the eyes of visitors and potential students. The rotary is irrigated for the same reasons, but also since the Beech tree located directly in the center of the rotary is a historic tree that needs to be preserved. That beech tree has been a symbol of WPI since its planting some sixty years ago.29 Along with the historical value, the beech tree is also one of the first objects someone will see when entering the main entrance to WPI. The final system amongst the WPI ball fields needs the most watering. This area is always used during anytime the fields are not covered in snow. Having an irrigated field is necessary for proper maintenance of a baseball/softball field. Previously to the installation of the system the grass area was always destroyed from the wear and tear of every activity that utilized the area. With an irrigation system in place, the maintenance of the outfields and infields will be much easier and will attract more athletes looking for decent playing fields. As for the current teams, the play will improve greatly, since the grass has always been destroyed during the winter season and through extensive use without constant watering and rejuvenation. To properly irrigate any area of the grounds irrigation is required.

Soil30

The soil is maintained by taking pH levels of the various sections of the campus. Currently WPI Grounds Services measures forty-two separate locations around the campus. Every year the pH level is taken and measured. In order to maintain the proper pH levels, lime is added to raise the pH level to the proper acidity level. This is

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[29] Miller, John. "WPI Alumni: The Bridge" <http://www.wpi.edu/Admin/Alumni/Bridge/0703.html> July 2003.

[30] Klocek, Ronald. "Soil PH Levels." 2000.

necessary for the grass to grow properly. Fertilization is also necessary and is described in length in the 'Fertilization' section. See Appendix E for a complete pH level chart.

Disease and Insect Control

Disease and Insect control is not a big concern at WPI. The only process that the groundskeepers perform related to insects is during the summer lawn-care program. The groundskeepers are instructed to check the lawn for abnormal amounts of insects. In the bed maintenance program, groundskeepers are instructed to check plants for insect damage during the summer months. These programs are inadequate and need to be revised. Nowhere in the maintenance programs does it state that the lawn or flowerbeds be sprayed with pesticides, herbicides, or insecticides. Herbicides are necessary for proper disease prevention, without them the grass will die if infected with certain diseases. Mr. Klocek explained that no such spraying was involved in any of the maintenance activities. He did however explain that when there are bee hive problems, he contracts the work out to Brahman Chemical company.31

Pruning

Pruning is a process that involves removing branches from trees that are unnecessary, dead, or in the way of power lines, lights, buildings, etc. WPI Grounds Services currently budgets for about $20,000 a year for pruning and tree care. For the most part, WPI out sources its pruning to Bartlett Tree Company, which is a global leader in scientific tree care. Their local office is located in Worcester on Grove Street; however, they have multiple locations across twenty-seven different states, Canada, Ireland and the UK.32

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[31] Klocek, Ron. Interview with Ron Klocek. Recorded by T.J. McLaughlin. April 1, 2004.
[32] Bartlett Tree Company. http://www.bartlett.com/au400.cfm 2003.

The campus as of now is divided into ten different pruning zones. Each year one zone is worked on and the trees in that zone are pruned, trimmed and cared for. In the interview with Mr. Klocek, he described that the current process is insufficient and should be modified. He explained that six zones would be optimal. This change is necessary because the trees need to be pruned more often then they presently do. Not only did Mr. Klocek mention the zoning needed to be changed, but like the rest of the budget, the tree care budget should be doubled to $40,000 a year. This would help pay for trees that actually need to be pruned each year.

During windstorms and ice storms severe damage to trees is expected. After a storm as such, the crew is instructed by Mr. Klocek to do a run through of the campus to look for any potential damage done by the storm. Bartlett Tree Experts are also called to come in and give professional opinions about the status of the trees after a storm. For the most part they are on an 'on-call' basis. Mr. Klocek explained that this process accounts for approximately forty hours per year.33

Snow Removal

Every member of the Grounds Services Department takes part in the snow removal process at WPI. As explained in the "Employees" section, the crew is on-call twenty-four hours a day. The groundskeepers are responsible to participate in snow removal from all walks, steps, hydrants, roads and parking lots owned and managed by WPI. In addition to the snow removal, they must undertake such tasks as salting and sanding of all the areas mentioned previously. WPI currently owns numerous snow shovels along with a Toro Snow Thrower and an Arien's Snow Thrower.34 Most of the

[33] Klocek, Ron. Interview with Ron Klocek. Recorded by T.J. McLaughlin. April 1, 2004.
[34] Klocek, Ronald. "Plant Services Vehicles Data" 2000.

parking lots are cleared by plows that are attached to a couple of the pick-up trucks owned by WPI. At night when the snow falls, the WPI Grounds Services works through the night to make sure all the paths leading to campus, all the sidewalks, and all parking lots are cleared of the snow. Then once all the snow is removed they make sure all walkways are salted and sanded to ensure the safety of the students and faculty of WPI.

The snow removal process is usually on an overtime schedule, therefore extra costs are incurred. The overtime is recorded by Mr. Klocek every year and is tallied up at the end of the year in order to keep tract of how much it costs in overtime wages to remove the snow from the campus and make it safe for students, visitors, and professors. In 2002, there was a total of 658.5 overtime hours, in 2003, there was 1,353 hours, and in 2004 there was 674 overtime hours. The complete overtime charts can be seen in Appendix I. The breakdown between plowing and salting overtime hours can be seen in Figure 2.4 below:35

Table 2.4: WPI Overtime Hours

Figure 5	2002	2003	2004
Salting	346.5	247	137
Plowing	312	1106	537
Total (hrs.)	658.5	1353	674

Litter Control36

As explained previously in the turf and lawn care section, each time the groundskeepers begin to treat the lawn they begin by picking up branches, twigs, papers, stones, and any other debris from the lawns. Controlling the litter in an inner-urban school is very difficult, especially in the city of Worcester. Every groundskeeper and gardeners' duty is to make sure the campus looks the best it possibly can. Litter is a

[35] Snow Removal Overtime Hour Information. Ron Klocek. 2002, 2003, 2004.
[36] Klocek, Ron. Interview with Ron Klocek. Recorded by T.J. McLaughlin. April 1, 2004.

problem that occurs from a person's laziness to not throw something in the trash. With this in mind, they must make sure there is nothing on the ground that should not be there. Mr. Klocek explained that litter control is a big issue on campus and is done on a daily basis by each member of his crew. He explained that each day each worker goes around the campus for approximately two hours a day picking up litter and trash. The only way this problem can be controlled is by making sure there are adequate trash disposal barrels located all over the campus.

Appendix B: Annotated Bibliography

United States Census Bureau

The Census Bureau website was used to gain information regarding employment figures, salary figures and other numerical facts related to jobs and census information. This was basically used for the gathering of background information.

www.landscapemanagement.net

Again used in the gathering of background information, this website provides information regarding landscape management figures and postulations. This website is used for the majority of the time by people within the grounds maintenance industry.

E-Grounds IQP; 2004

Last year's E-Grounds IQP was used extensively throughout this project as a source for background information and figures. The entire background section of last year's project is listed in Appendix A, and the results reached in last year's project were used as the foundation of this project.