

Fall 2010

Exploring sustainable environmental management practices for golf courses in semi-arid environments

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**EXPLORING SUSTAINABLE
ENVIRONMENTAL MANAGEMENT
PRACTICES FOR GOLF COURSES IN
SEMI-ARID ENVIRONMENTS**

Angelica V. Gurule

**Master of Science of Sustainable Environmental Resource
Management**

University of Malta

2010

**EXPLORING SUSTAINABLE ENVIRONMENTAL MANAGEMENT PRACTICES
FOR GOLF COURSES IN SEMI-ARID ENVIRONMENTS**

A dissertation presented in part fulfilment of the requirements for the Degree of Master of
Science in Sustainable Environmental Resource Management.

Angelica V. Gurule

November 2010

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ABSTRACT

Angelica V. Gurule

EXPLORING SUSTAINABLE ENVIRONMENTAL MANAGEMENT PRACTICES FOR GOLF COURSES IN SEMI-ARID ENVIRONMENTS

For the past several years NM government officials have been working to increase economic growth via tourism in NM. As a result several dozen golf courses have popped up around the state. Golf courses are conceived to be problematic as they consume large quantities of water and typically use lots of harmful pesticides to manage turfgrass. Water scarcity has already shown its face in NM: there are drought plans in place and growing evidence that illustrates the decrease in precipitation and an increase in temperatures, which will further reduce water resources. The scope of this paper is to analyze the environmental management strategies of the Marty Sanchez Links de Santa Fe Golf Course, which is located in a semi-arid high desert region. Many areas were examined including land use and development, integrated pest management, water management, turf management, and energy and waste management. Most data was collected via literary reviews as well as data collected on the field and observations of golf course management tactics. MSL golf course has proven to implement sustainable environmental management strategies that will not only sustain the longevity of the MSL golf course, but also reduce the impact of golf courses in semi-arid regions while protecting the health of the general public and the environment. Furthermore, the MSL golf course has proved beneficial to the local economy both directly and indirectly. The MSL golf course is a leader in sustainable environmental resource management, and these results can be used by other golf course managers who aim to reduce their environmental impacts while avoiding unnecessary costs.

Tom Benzing, Wayne Teel, and Maria Papadakis

MSc SERM

November 2010

GOLF COURSE, SUSTAINABLE, WATER, TURFGRASS, SEMI-ARID, HIGH-DESERT

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ACKNOWLEDGEMENTS

City of Santa Fe, Public Works Department

Fabian Chavez, Parks Division Director

Martin Lujan, MRC Manager

Brian Romero, Wastewater Treatment Plant Acting Director

Louis Orozco, Wastewater Treatment Plant Superintendent

Chris Blea, MRC Certified Plumber / Supervisor

Jennifer Richardson, MRC Information Coordinator

Nicholas Schiavo - Energy Specialist

Bob Wood, City of Santa Fe IPM Manager

John Allen, Superintendent of MRC Sports Complex and Marty Sanchez Links de Santa Fe Golf Course

John Romero, MRC Irrigation Technician

Gilbert R. Martinez, City of Santa Fe Project Administrator for the Public Works Department

Larry McFarland, Editor

ACRONYMS

EPA – Environmental Protection Agency

ET - Evapotranspiration

IPM – Integrated Pest Management

MRC – Municipal Recreation Complex (which includes both Marty Sanchez Links de Santa Fe golf course and the sports facility)

MSL – Marty Sanchez Links

NM – New Mexico

NMED – New Mexico Environment Department

Pro Shop – Golf Professional Shop

US/USA – United States/United States of America

USEPA – United States Environmental Protection Agency

INTRODUCTION

For the past several years, New Mexico (NM) government officials have been working to increase development and economic growth within the state. One strategy has been to enhance the tourism industry via outdoor sports and recreation by investing in golf courses, parks, and open space and trails. As a result, several dozen golf courses have been developed across the state. According to the State of New Mexico Tourism Department, “NM has over 70 golf courses from executive-style golf to Professional Golf Association tournament-caliber courses.”¹

Golf courses in semi-arid environments are often conceived to be unsustainable and detrimental to the environment. More specifically golf courses require tremendous amounts of water and chemical inputs, in order to maintain lush and pristine turfgrass. This study will assess the current environmental management strategies of the Marty Sanchez Links de Santa Fe Golf Course in NM, a high-desert, semi-arid region with an emphasis on water consumption and Integrated Pest Management (IPM). Research findings will be analyzed to determine the economic and environmental benefits of implementing sustainable environmental management practices. These findings along with recommendations will be given to the golf course manager and superintendent. Lastly, this research will serve as a guide to golf course managers interested in reducing the environmental impact and alleviating some financial cost of their courses.

¹ State of New Mexico Tourism Department: <http://www.newmexico.org/play/> (18 Feb 2010)

BACKGROUND

NEW MEXICO

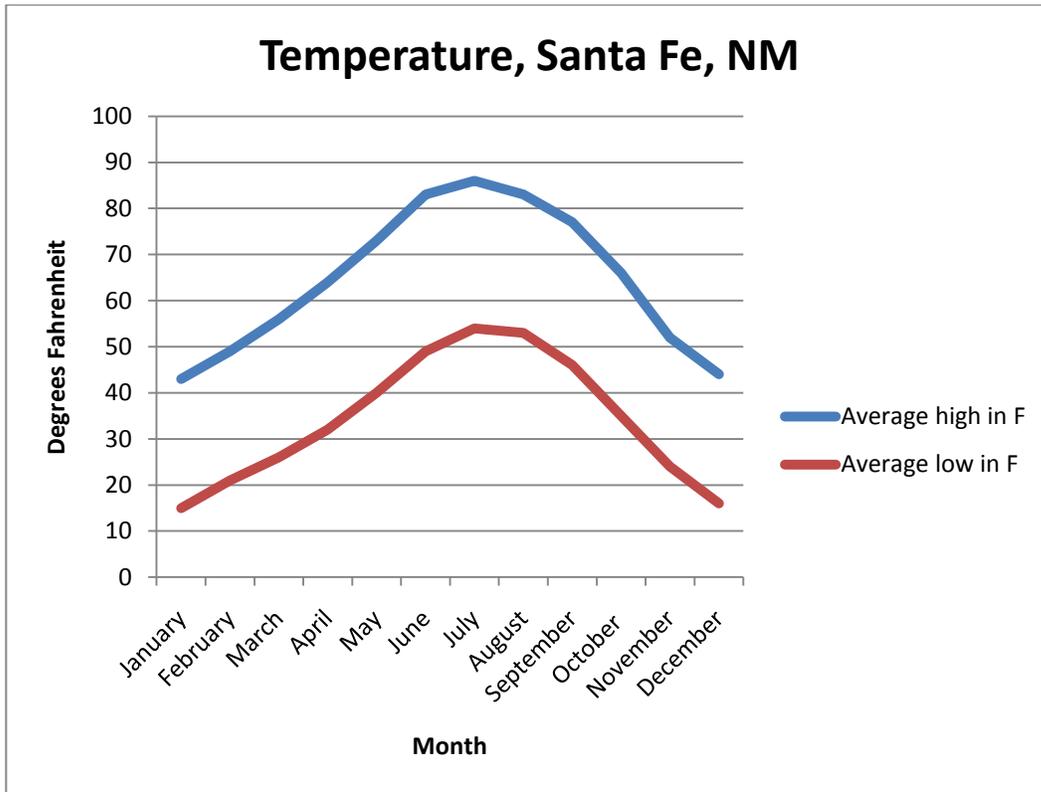
NM is a semi-arid environment located in the southwestern region of the United States (US). Within the state itself there are multiple climatic zones all based upon topography and elevation, which includes the northern and southern regions as well as the higher and lower altitudes ranging between “13,161 feet at Wheeler Peak and 2,817 feet above the Red Bluff Reservoir” (New Mexico State University, 2010). NM as a whole experiences all four seasons – spring, summer, autumn, and winter. As a result the climate conditions of the region strongly influence the turfgrass varieties, maintenance techniques, and irrigation methods that are selected to maintain the highest quality playing conditions. In Santa Fe, NM, the average annual precipitation is 14.2 inches. The temperature variations between seasons can vary from 86°F (30°C) in the hottest summer month, July, and can drop to mid 15°F (-9°C) in the coldest winter month, January (U.S. Climate Data, 2010). As golf courses must be able to survive under these variable and often harsh climatic conditions the primary ingredient for their survival is an adequate water supply. Therefore, if the average annual precipitation in Santa Fe, NM is 14.2 inches and the required amount of water at the MSL golf course is 20 inches of precipitation per year, then the extra 5.8 inches of precipitation must be acquired from an alternative water source. This calculation does not include potential water lost to evapotranspiration (ET) or any other variable that may increase or decrease the need for water. ET is the amount of water lost via plant transpiration and soil and plant evaporation. The average high and low temperature and average precipitation data is tabulated below in Table 1. Santa Fe, New Mexico Climate – Temperature and Precipitation, and this data is illustrated in Figure 1. Temperature in Santa Fe, NM, and Figure 2. Precipitation in Santa Fe, NM, respectively.

Table 1. Santa Fe, New Mexico Climate – Temperature and Precipitation

Month	Average high in F	Average low in F	Average high in C	Average low in C	Average Precipitation - inch
January	43	15	6	-9	0.59
February	49	21	9	-6	0.51
March	56	26	13	-3	0.83
April	64	32	18	0	0.71
May	73	40	23	4	1.26
June	83	49	28	9	1.22
July	86	54	30	12	2.24
August	83	53	28	12	2.13
September	77	46	25	8	1.65
October	66	35	19	2	1.3
November	52	24	11	-4	1.06
December	44	16	7	-9	0.67

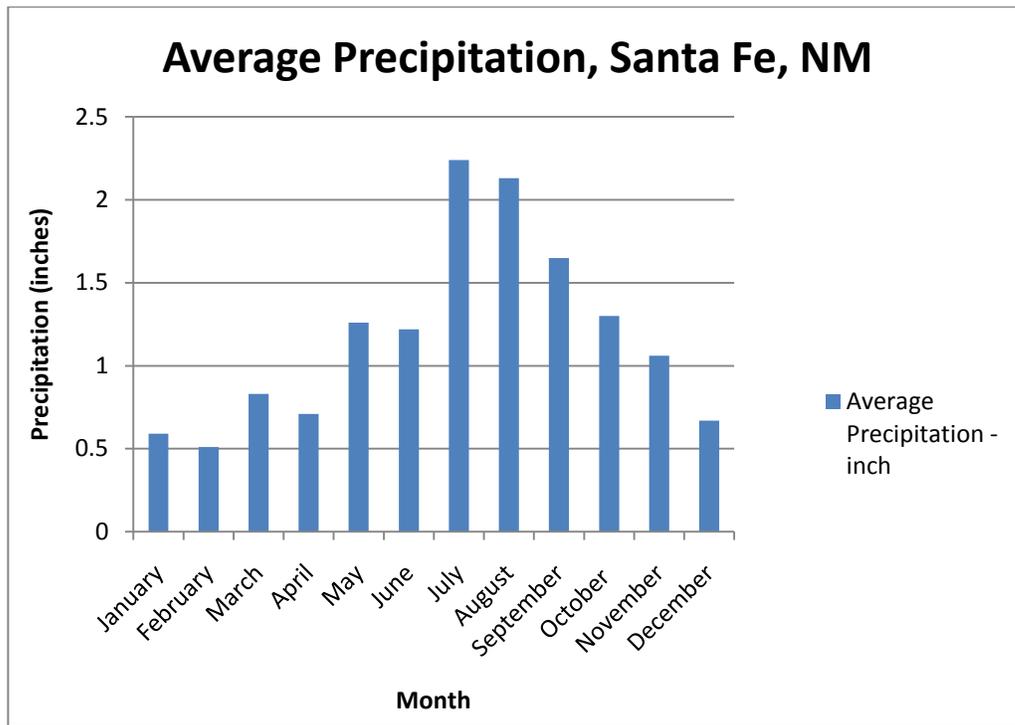
Source: (U.S. Climate Data, 2010). The above data represents average high and low temperatures in Fahrenheit and Celsius on a monthly basis as well as the average precipitation in inches per month for Santa Fe, New Mexico.

Figure 1. Temperature in Santa Fe, New Mexico



Source: (U.S. Climate Data, 2010). This graph is a month-to-month break down illustrating a 30-degree temperature differentiation from night to day in Santa Fe, New Mexico. This graph illustrates both diurnal and seasonal temperature fluctuations.

Figure 2. Average Precipitation in Santa Fe, New Mexico

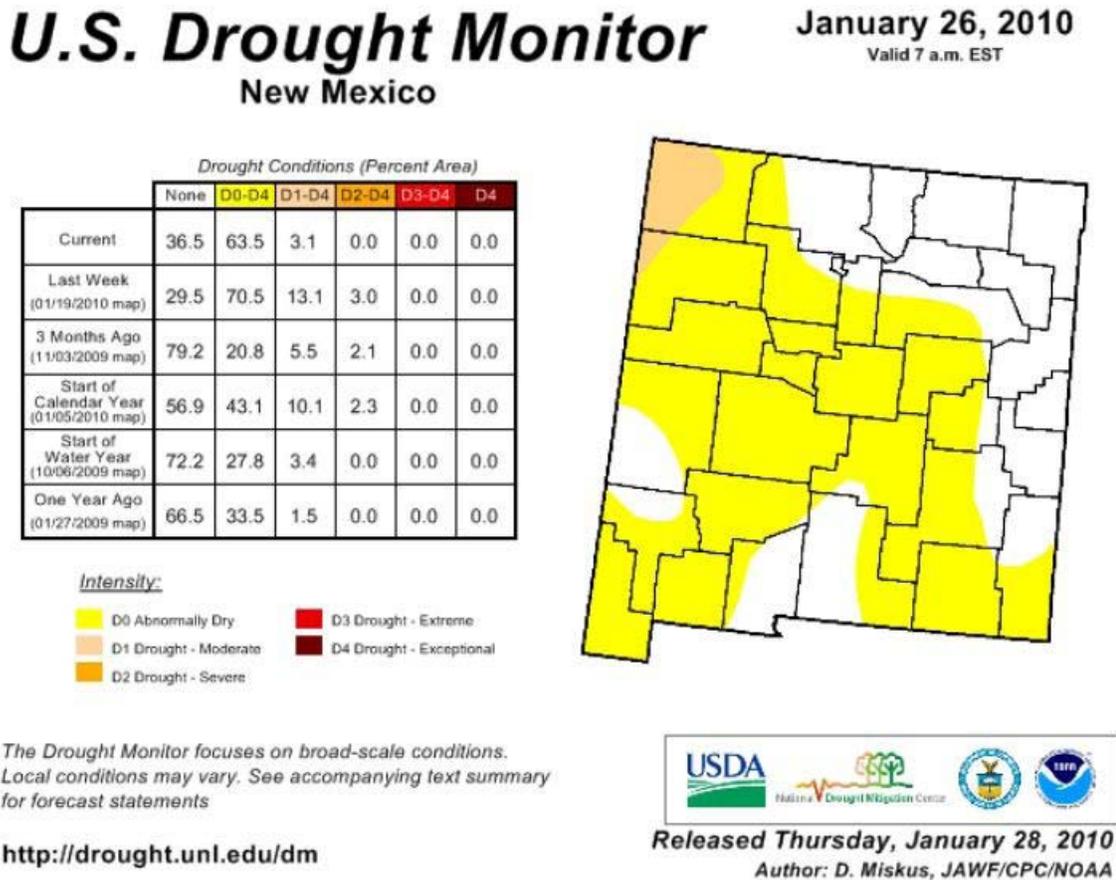


Source: (U.S. Climate Data, 2010). This is a month-to-month breakdown of average precipitation in Santa Fe, New Mexico.

It is interesting to note the parallel between precipitation and temperature in Santa Fe, NM; as the average temperatures begin to increase the average precipitation also begins to increase; this also relates to a decrease in temperature and a decrease in precipitation. It is also interesting to note that Figure 2. Average Precipitation in Santa Fe, New Mexico illustrates precipitation and does not include run-off data, which typically begins around March or April and contributes to the overall available water resources and the replenishment of groundwater aquifers as well as surface water systems such as streams, rivers, and lakes.

In the New Mexico Drought report, developed in January 2010, the maps depict moderate to severe drought conditions, with abnormally dry conditions over Central and Southern NM.²

Figure 3. New Mexico Drought Report



The New Mexico Drought Status Report illustrates “abnormally dry” conditions in most of the state, including Santa Fe, New Mexico.

Although recent precipitation events have alleviated some of the burden, concern for water security is still a critical issue. Needless to say there are competing interests for water resources in all sectors, such as public and private consumption, agriculture, manufacturing, and other industries. As a result of water scarcity, conservation efforts are being made. For example, “Las Campanas [private golf resort] was exploring taking as much as 10 percent

² New Mexico Office of the State Engineer: Governors Drought Task Force:
<http://www.ose.state.nm.us/DroughtTaskForce/MonitoringWorkGroup/2010-01-xx-dmwg-rpt.pdf>

of its turf out of play to save water, said Bob Buddendorf, chairman of the members' advisory committee" (Sun Country Golf, 2010). A 10 percent reduction in turf calculates to 14 acres of turf removal as Las Campanas private golf resort has 140 irrigated turf acres.

MARTY SANCHEZ LINKS GOLF COURSE

The Municipal Recreation Complex (MRC) encompasses the Marty Sanchez Links (MSL) golf course and sport facility, which includes baseball, rugby, soccer, softball, volleyball, and BMX fields. The MSL golf course was built to USGA specifications, including the Herringbone design bunkers and water harvesting drain system designed by Baxter Spann. The MSL golf course has been successfully operating since its opening in 1998. Avid golfers enjoyed 43,000 rounds of golf in the past year at the MSL golf course (Richardson, 2010). MSL golf course is a 27-hole course, including one 18-hole championship course and one 9-hole executive course, also known as "Great 28". The Great 28 is actually 8 par 3's and 1 par 4, thus adding up to 28 for par. There are three practice greens, 27 fairways, 30 greens, and 72 bunkers, all totaling 7 miles of a golf player's delight.

MSL golf course is located in the northern part of the state on a high-desert region, approximately 7,600 feet above sea level. According to the New Mexico Drought Report, Figure 3, MSL golf course is located in an "abnormally dry" region; as a result the climate in the area is variable and experiences significant diurnal and seasonal cycles. MSL golf course is surrounded by the beautiful Sangre de Cristo Mountains to the east, Jemez Mountains to the west, Sandia Mountains to the south, and the Ortiz Mountains to the southeast. The vistas are breathtaking and provide the perfect setting for a game of golf.

The golf course itself has several amenities including the Golf Professional Shop (Pro Shop) for every golfer's needs, including new golf shoes, tees, or clubs or to sign-up for Chemical Sensitive notifications. The Chemical Sensitive distribution list notifies golfers if there has been any type of chemical sprayed on the course. This allows chemically sensitive players to plan their playing time on the course accordingly. This chemical sensitive distribution list is also beneficial to players traveling from far distances to play at the MSL golf course. The Back 9 Grill restaurant and bar at the MSL offers delicious and affordable food and beverages for golfers after a day of golf. "The Pro Shop and the Back

9 Grill are managed through external contractors, from which the City of Santa Fe receives royalties” (Richardson, 2010). Other services offered by MSL golfers include golf lessons, two putting and pitching greens, practice and sand bunkers, and a driving range.

The MSL golf course has a permanent staff of nine full-time, year-round employees, which includes the crew and administrative staff. The golf course also has seasonal employees and volunteers that contribute to the smooth operations. Volunteers are typically compensated with a certain amount of playing time at the MSL golf course. This provides a great opportunity for volunteer staff to become more familiar with the course as well as the game of golf. Golf courses not only promote tourism, they also provide jobs in the golf industry as well as in hotel and restaurants as golfers travel from near and far to play a new course.

MSL golf course is operated and managed by the City of Santa Fe Municipality and is known as the “most affordable” golf course in the state of NM. A weekday 18-hole greens fee is a minimal \$32.75, while a 9-hole greens fee is \$23.25, and the cost to rent a golf cart is \$16 and \$9, respectively.³ There are also additional discounted prices for juniors and seniors. An annual membership, Player’s Club, is \$125, which gives discounts at the restaurant, Pro Shop, and on golf course greens fees.

“Municipal golf has been around for a long time, says National Golf Foundation (NGF) President and CEO Joe Beditz, and it plays an important role in the overall mix of supply in the United States. Municipal Courses fill a need for millions of less-affluent golfers who enjoy not only the game, but its affordability through a government-owned venue. Eliminate that price point afforded at these facilities and those players will cease to play” (Leslie, 2010).

Not all NM golf courses are as affordable as the MSL golf course; this may be attributed to the fact that MSL golf course is a municipal golf course. However, to give an example, the price to play golf at Las Campanas private golf resort, which is only a few minutes drive from MSL golf course, and to better define what is meant by the term “most affordable,” the Las Campanas private golf resort requires a \$90,000 initiation fee for membership at its 36-hole facility (Sun Country Golf, 2010).

³http://www.linksdesantafe.com/information/ldsf_green_fees.htmlhttp://www.linksdesantafe.com/information/ldsf_green_fees.html

Figure 4. Google Earth Image of Marty Sanchez Links De Santa Fe



Source: Google Earth Accessed October 19, 2010. This image illustrates the MSL golf course on the top left, symbolized with the red marker and the sports facility to the bottom right. The green areas represent the turfgrass, i.e., fairways, greens, sports fields, etc. The dark black areas represent the water reservoirs, which are used to irrigate the MRC Sports Complex.

The MSL golf course has several self-sustained restrooms located around the course, which are completely “off the grid” meaning they do not have any connection to electricity or gas utilities. The restrooms are installed with solar panels to generate warm water for hand washing and lighting. There are also skylights in each restroom, which utilize the sunlight to provide an additional light source.

Several ponds located around the MRC serve as reservoirs for the reclaimed wastewater that is used for irrigation. Not only do these ponds hold water, they are also hot spots for biological diversity. Several different types of birds as well as ducks, fish, and amphibians populate the ponds. The ponds provide these animals with an artificial habitat, which further increases biodiversity in the area. These ponds have also invited species that would have not otherwise been found in the region. For example, during migration season, blue herons came into the MSL golf course and successfully nested (Lujan, 2010). This is obviously a beautiful sight to see, and for the birds it provided a refuge and resting place for their journey south. Unfortunately, these ponds are emptied during the winter months to avoid pipes freezing and other problems. The emptying of the ponds could cause stress to the species that are displaced during these months. The trees around the ponds serve as a protective barrier between the course and the pond, combat erosion, and provide a natural habitat. Unfortunately, the trees around the pond are maintained so as to reduce the amount of water the trees consume from the ponds; tree maintenance is often disruptive and could cause stress to the animals that inhabit the area. The tree maintenance to some extent conflicts with enhanced biodiversity, and a minor change in the tree maintenance schedule may reduce such stress. For example, tree maintenance can be done in winter months during the migration season, or when the ponds are emptied, which will minimize the disruption to the species.

A healthy balance of native and other drought-tolerant trees, shrubs, flowers, and grasses line the boundary of the course, including one-seed juniper, pine trees (pinon), Santo Lina grass, chamisa, choya cactus, yucca, Mexican Hat, coreopsis, mountain mahogany, purple aster, purple spurge, Blue grama grass, and Buffalograss. “Buffalograss and blue grama are popular choices where low water use and low maintenance are the primary selection criteria” (Goldberg, 2000). Allowing native plants to grow instead of landscaping the area with non-native flowers and plants also conserves water and saves money that would be spent creating an artificial landscape. Allowing these native species to inhabit the area also reduces maintenance and labor costs that would be needed to properly care for a man-made landscape.

OBJECTIVES

The exploratory research conducted for this study will provide a thorough evaluation of current environmental management strategies, which aim to reduce water consumption and minimize environmental impacts of golf courses in semi-arid environments. The results will also be provided to the MSL golf course manager in Santa Fe, NM. The initial assessment of MSL golf course evaluates the land use and development of the current site of MSL golf course to determine the environmental and economic impacts of its development. It also evaluates the current Integrated Pest Management (IPM) strategies to determine the environmental impacts and potential cost savings as a result of IPM. Water management was also evaluated and focuses specifically on water quality, water availability, irrigation methods, technology, and regulations, and water conservation strategies as well as the cost savings that result from conservation strategies. Turf management was also evaluated as it directly relates to the water management and IPM. Energy and waste management strategies were also evaluated and analyzed to provide opportunities for improvement that will result in potential cost savings, as well as energy and waste reductions.

LAND USE & DEVELOPMENT

NM is the fifth largest state in the US, and typically land acquisition for golf courses is not a problem; therefore, the amount of land used for the development of the MSL golf course was not a major concern.

Golf courses, although they can require large plots of land, can also increase the property desirability and value of the surrounding areas. Since the development of the MSL golf course and sports complex, the surrounding area has grown substantially. There are now commercial and residential establishments such as an animal shelter, the State of NM Archeology building, the Caja del Rio Landfill, NM Game and Fish Headquarters, and one of the most expensive residential communities in Santa Fe County, Las Campanas and the Las Campanas two 18-hole private golf course.

The site chosen during golf course development can either positively or negatively impact an area. For example, a portion of the MRC sports facility was constructed on the old city landfill. Transforming this once degraded site has proven to be an excellent land management decision as the area would have otherwise been vacant, and now it provides a beautiful recreational area for the community. The Bureau of Land Management (BLM) previously managed the site chosen for the MSL golf course; however, the City of Santa Fe acquired the property over a decade ago. Since the property was BLM, the property was vacant and thus no residents were displaced as a result of the development of the MRC. Although residents were not displaced, the development of the golf course could have negatively impacted the biodiversity and other ecological functions of the area. Prior to the development of the MRC the site was essentially untouched and its only inhabitants were wild animals, birds, insects, reptiles, trees, flowers, grass, and the like. It is relevant to infer that due to the construction and development of the MRC Sports Complex, fragmentation occurred at some level and caused impact to the surrounding environment. Prior to the development of the MRC sports facility the area was essentially a corridor for migrating animals and provided a refuge from the urban environment. A result of developing virgin properties, such as the site chosen for the MSL golf course, is that there are often unintended consequences. The construction of building and roads resulted in a fragmented landscape and ultimately interferes with the once-undisturbed corridor. There was also some disturbance in the landscape due to the necessity to alter the topography to construct a desirable playing field, which consequently resulted in the displacement of insects, birds and animals and may have increased nutrient and soil loss to erosion.

“Sometimes we have no choice but to disturb these relationships, but we should do so thoughtfully, with full awareness that what we do may have consequences remote in time and place” (Carson, 1962).

Unfortunately, there were some minor disturbances as result of the development of the MSL golf course; however, the course itself now provides an artificial habitat and corridor for many animals, birds, fish, and insects with its flourishing ponds, native landscapes, and acres of rolling turfgrass which significantly decreases erosion. It also provides a refuge and sanctuary for migrating birds and animals. Since the development of the golf course there has been significant residential and commercial growth in the area, which illustrates

the desirability of developing in the area and more importantly the financial growth that contributes to the NM economy. The site chosen for development significantly enhanced the value of the area, by recovering a once degraded landfill site and transforming it into a sports complex that is beneficial for the community.

INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) is an alternative and fairly modern approach to managing pests in a safe and environmentally friendly way. IPM usually avoids the use of synthetic pesticides and encourages the use of less-toxic, less-harmful methods. IPM can result in potential cost savings due to the avoidance of costly pesticides. IPM also alleviates environmental and public health impacts that arise from using harmful and toxic pesticide chemicals.

It was Rachel Carson's book *Silent Spring* that created an environmental uproar and sent government officials searching for an environmentally safe and friendly alternative to chemical pesticides. *Silent Spring* shined the light on the many ill effects of synthetic pesticides with a strong emphasis on the so-called "harmless pesticide" DDT (short for dichloro-diphenyl-trichloro-ethane). DDT was first used in the military arena as a means to combat lice from thousands of soldiers and the like, it was also used to help farmers cultivate fruitful crops (Carson, 1962). By the 1950s the FDA declared, "it is extremely likely the potential hazard of DDT has been underestimated" (Carson, 1962).

"But such substances [DDT] are so potent that a minute quantity can bring about vast changes in the body. In animal experiments, 3 parts per million (ppm) has been found to inhibit an essential enzyme in heart muscle; only 5 ppm has brought about necrosis⁴ or disintegration of liver cells" (Carson, 1962).

It was also Rachel Carson who rang the alarm and left American consumers questioning the safety of the chemicals being used and demanded that government officials implement state and federal regulations regarding the protection of the environment from harmful pesticide chemicals. Rachel Carson asked and answered the following question in regards to the application of pesticides:

⁴ Necrosis is defined by Webster's New Dictionary as the death or decay of tissue in some body part.

“Can anyone believe it is possible to lay down such a barrage of poisons on the surface of the earth without making it unfit for all life? They should not be called “insecticides,” but “biocides” (Carson, 1962).

Rachel Carson’s *Silent Spring* strongly influenced the change in how the US government allows chemical products to enter the market, not only because their side-effects are sometimes unknown and are often extremely harmful to the health and safety of the general public and the environment, but also because there is most likely an alternative solution that is less toxic and often safe for both humans and the environment.

“We allow the chemical death rain to fall as though there were no alternative, whereas in fact there are many, and our ingenuity could soon discover many more if given opportunity” (Carson, 1962).

Rachel Carson was absolutely right; if given the opportunity, alternative solutions to using harmful chemical pesticides could be discovered, and they have been. Indeed, there are various methods that have been “discovered” that are less toxic to the people and our planet. An alternative choice to synthetic pesticide usage is to engage other pesticide-free methods. In great appreciation for Rachel Carson and also to the US EPA, there have been many aggressive state and federal regulations that prohibit the use of synthetic pesticides as a first choice and encourage the use of non-pesticide approaches in IPM plans.

The MRC is managed by the City of Santa Fe, and the MSL golf course must be operated in compliance with City policies including the City of Santa Fe Integrated Pest Management Policy, referred to as Ordinance No. 2001-10. Due to the stringency of this policy, the City of Santa Fe IPM Policy overrides any State or Federal IPM ordinances.

“The governing body of the city of Santa Fe hereby finds and declares that it shall be the policy of the city of Santa Fe to eliminate or reduce pesticide application on city property to the maximum extent feasible” (City of Santa Fe, 2001-2010).

In simpler terms, pesticide use is not allowed without a waiver from the City of Santa Fe Integrated Pesticide Manager. This Ordinance applies only to public property owned or leased by or from the City of Santa Fe. This stringent ordinance is to the utmost benefit of the environment and the general health and safety of Santa Fe residents and New Mexicans. While this ordinance applies only to public property owned or leased by or from the City of Santa Fe, pesticides cannot be confined to a certain area and thus can be transported

throughout the city and state, directly or indirectly affecting every living creature they come into contact with. Sometimes humans are so far removed from nature that it is hard to conceive that a pesticide applied at the MSL golf course could potentially affect someone who never stepped foot on a golf course. However, Rachel Carson makes a clear statement as she illustrates how chemicals such as DDT travel through the food web and eventually make their way into each and every one of our lives.

“One of the most sinister features of DDT and related chemicals is the way they are passed on from one organism to another through all the links of the food chains. For example, fields of alfalfa are dusted with DDT; meal is later prepared from the alfalfa and fed to hens; the hens lay eggs, which contain DDT, or the hay, containing residues of 7 to 8 ppm, may be fed to cows. The DDT will turn up in the milk in the amount of 3 ppm, but in butter made from this milk the concentrations may run to 65 ppm. Through such a process of transfer, what started out as a very small amount of DDT may end as a heavy concentration” (Carson, 1962).

Although an IPM plan has not yet been officially established for the MSL golf course; the current IPM manager is highly knowledgeable of the pest problems at MSL golf course and extremely experienced when it comes to successfully managing pest problems using less-toxic or alternative approaches. After assessing the MSL golf course IPM strategies and interviewing turf managers and the superintendent, it is evident that even though there is not a specific IPM plan for the MSL golf course, it does not mean that the MSL golf course is not already proactively engaged in successful IPM strategies. The City of Santa Fe Pest Management Policy defines an IPM as follows:

“Integrated pest management means a decision-making process for managing pests that uses monitoring to determine pest injury levels and primarily uses cultural, mechanical, physical, and biological tools to minimize health, environmental, and financial risks. The method uses extensive knowledge about pests, such as infestation thresholds, life histories, environmental requirements and natural enemies to complement and facilitate biological and other natural control of pests. The method uses least toxic synthetic pesticides only as a last resort to manage pests” (City of Santa Fe, 2001-2010).

However, to extend the knowledge base and as a means to further educate the staff of MSL golf course about IPM, it is highly recommended to develop an IPM plan specific to MSL golf course. An IPM plan will allow the current and future staff of MSL golf course to

understand the current and historical pest problems at MSL golf course as well as the successful and unsuccessful solutions. An IPM will serve as a guide to employees about how to manage pests on the golf course as well as a tool to forecast the outcomes of using certain strategies. “It is essentially a contract between the superintendent, the crew, and the golfers about how decisions will be made and what results can be expected” (Schumann, Vittum, Elliot, & Cobb, 2002). Another advantage that results from a well developed IPM plan is the potential cost savings, which derive from maintaining sufficient records and reducing the amount of time and labor spent trying to manage a certain pest. The City of Santa Fe has an IPM policy, which can be used as a guide for the development of the custom IPM plan for the MSL golf course:

- A. “Prevent pest problems through non-pesticide means as much as possible;
- B. Monitor each pest habitats to determine pest population, size occurrence, and natural enemy population, if present. Identify decisions and practices that could affect pest populations. Keep records of such monitoring;
- C. Set for each pest at each site and identify in an IPM implementing plan, an injury level, based on how much biological, aesthetic or economic damage the site can tolerate; and
- D. Consider a range of potential treatments for the pest problem. Employ non-pesticide management tactics first.
- E. Conduct ongoing education programs
- F. Monitor treatment to evaluate effectiveness” (City of Santa Fe, 2001-2010).

MSL golf course currently implements many of the following pest management strategies, which are in accordance with the City of Santa Fe IPM policy: biological, physical and mechanical, prevention, modification of management practices, and temperature.

A biological solution is one in which natural predators or parasites are used as a means to minimize the threat of unwanted pests, i.e., using snakes to reduce mice populations. However, it is important to note that the MSL golf course is currently trapping and relocating snakes, which is non-beneficial as they can be used to control the mice populations. Natural bacteria such as *Bacillus thuringiensis* (Bt) can also be used as an alternative to synthetic pesticides.

Physical and mechanical controls can involve traps, hand-weeding, and barriers or other exclusion methods. Often times unwanted weeds in hard to reach places require hand-

weeding techniques. The method of exclusion can also be used as an effective solution. Using exclusion as a control is as the name implies and simply excludes a pest from a given area. Most exclusion strategies can be integrated into the building design by installing screens on windows and doors or properly sealing windows and doors to exclude pests such as flies, wasps or bees, spiders, and ants from sneaking inside. Installing a door sweep is another exclusion method and simply prohibits spider, centipedes, and other unwanted insects from entering the building. If the Back 9 Grill restaurant suddenly has problems with unwanted pests in the kitchen or dining area a simple light test can help alleviate the problem. If light can be seen underneath the door, the door sweep needs to be replaced. During wintertime, as the temperature begins to decrease there is an increase in pests inside buildings. As a preventative measure the light test can be implemented throughout the MRC to exclude pests from entering the buildings. A proper IPM should also include physical hand weeding methods to address noxious weeds such as clovers and dandelions. In general the MSL golf course putting greens have zero pest tolerance and thus weeds are not tolerated. Fairways on the other hand have a slightly higher tolerance for weeds and thus players will find a few clovers amongst the turf. The goal is to prevent weed growth in low-threshold areas, which include putting greens, walk ways, cart paths, flower spots, etc. However, the pest first needs to be properly identified; if not this could intensify the problem. For example, for every spurge pulled, it will create five more as all the seeds fall to the ground and the problem is compounded.

Prevention is another pesticide-free method and works effectively by eliminating the need for a pesticide by preventing a pest from being attracted to the area. For example, by cleaning the counter tops and floors, various pests such as cockroaches, ants, and fruit flies are not attracted to the area, thus avoiding the need for a pesticide. “Another opportunity for prevention is in the restaurant, by properly cleaning grills, vents, and the backing board behind the grill can prevent unwanted pests such as cockroaches” (Wood, 2010).

“Turfgrass diseases are best controlled with good management practices” (Goldberg, 2000). Often times the modification of management practices can reduce the pest incident rate on a golf course. Slight changes in the watering time, mending soil conditions (which is often difficult to do after the turf is in place; however, aeration can increase permeability and

benefit the health of the turfgrass), changing mowing heights or frequency, or increasing light penetration and air circulation by thatching and raking can increase the health of the turfgrass and reduce susceptibility to pests.

Another opportunity to prevent the use of pesticide is by means of altering the pH of the system to an unfavorable or intolerable condition. Often times species have a limited tolerance to changes in pH, and such changes will either cause the pest to leave the area or will kill the species as it is unfit to survive. Altering the pH is similar to the temperature solution. Altering the temperature to an unfavorable or intolerable temperature can be used to eradicate a pest. The change in temperature is often drastic and extreme to either freezing cold or boiling hot, i.e., freeze spraying insects such as wasps or flushing boiling hot water down an anthill.

The US EPA suggests the following “four-tiered approach” for implementing an IPM:

- “1. Set an Action Thresholds, the point at which pest populations or environmental conditions indicate that pest control action must be taken.
2. Monitor and identify pests accurately so that appropriate control decisions can be made, if at all necessary.
3. Prevent pests from becoming a threat, via cultural methods, selecting pest-resistant varieties, and/or planting pest-free rootstock.
4. Implement a control method once the action threshold, monitoring and prevention methods indicate that pest control is required and preventive methods are no longer effective or available” (Integrated Pest Management Principles).

Part of developing an effective IPM plan is to first identify the desired level of aesthetics or threshold level of a given location. This is referred to in step 1. “Set an Action Threshold” by the USEPA approach for implementing an IPM. For example, the Back 9 Grill restaurant would almost certainly have a relatively high level of aesthetics in the dining area, bar, and kitchen. If this level were rated on a scale of 1 to 10 the aesthetic level would be 10, which in this case means that this area has a high aesthetic value and thus requires zero tolerance for pests. However, the Back 9 Grill restaurant may have a lower aesthetic value, such as a six, for pests at the entrance or in the parking lot, where some pests such as ants or weeds would be tolerated. The MSL golf course has a high aesthetic

value and a low tolerance for pests on the putting greens and driving ranges compared to the roughs or fairways. “Tolerance levels are simply tools for making informed decisions. It is impossible to achieve perfection, so the superintendent and golfer together must determine tolerance levels or threshold levels” (Schumann, Vittum, Elliot, & Cobb, 2002).

The IPM solution often boils down to available finances and the decision of personnel management; for example, Disney Land has one of the most prestigious and stringent IPM plans, not to mention the finances to back it. Disney Land topiaries are trimmed with itty-bitty scissors to achieve perfection and avoid unnecessary mistakes (Wood, 2010). The reason so much care is taken for these topiaries is because they are photographed about 3,200 times per day and are a public attraction. Disney Land is known to have zero tolerance for insect problems; if the topiary were infested with pests it would be dug up and replaced immediately. If the same problem occurred at MSL golf course, it would be handled differently.

The next part of developing an effective IPM plan is to gather and document relevant information. Once the pest problems of the MSL golf course are properly identified, any information regarding the pest problem should be monitored and recorded. Keeping good data records will increase the effectiveness of an IPM plan. There are various approaches to begin tracking pest problems. One approach can be similar to the way health physicians track the health of their patients. For example, each green, fairway, or tee can have its own individual health record. Another option is to track pest problems either by the type of pest or by the species the pest is targeting. Data records should include as much information as possible, for example the time of year the problem occurred, weather conditions, moisture level, as well as the type of application used, how it was applied, and the success rate or problems encountered. These records will allow the IPM manager to recognize any patterns and thus implement preventative measures to reduce or avoid future occurrences of the problem. This is an excellent preventative measure that can save a lot of time and money and avoid any unnecessary outbreaks of pest problems.

At the MSL golf course, putting greens require the highest level of maintenance. The putting greens have occasional problems with fungus and insects. One insect that is known to cause havoc is the June beetle, also known as the June bug, or formally known as the

Phyllophaga. The June bug is generally bright green in color, but in NM they tend to be brown; their average size is about one inch. They mate in the summer months of June and July and lay their eggs in the soil. The larvae hibernate in the winter and feed on the roots of turfgrass for survival. They can cause serious injury and damage to the grass; if they eat all the roots there is nothing to keep the grass alive. June bugs are known to populate very rapidly, and knowing when the eggs are ready to hatch is crucial to managing the pest effectively. The June beetle larvae can be found in the month of May. Understanding this specific information can assist in the termination of these insects at their earliest form, using the least amount of pesticide possible. Treating this problem after the larvae hatch would be more problematic and would most likely require a larger quantity of pesticide. “If the greens keepers wait until late June, the pesticide solution must be increased to manage the pest appropriately, most often a 3% solution is required due to the large size of the June bug at the time of management” (Wood, 2010). One natural parasite that is used on the Japanese beetle is milky spore; however, the Japanese beetle is similar to yet different from the June bug and milky spore has not proven to be effective on the June bug.

Another problematic pest at the MSL golf course is snow mold. Snow mold fungus grows healthily in cool, dark, stagnant environments. The timing in application is essential to address this problem. “The snow mold should be addressed as early as February to avoid overgrowth in March and April” (Wood, 2010). This fungus likes acidic material; any time you have nitrogen it makes the soil more acidic and, vice versa, less nitrogen means less acidic soil. There are several solutions that can be implemented; however, the first option should always be a pesticide-free approach, such as a biological or cultural control. “Since the snow mold grows best in a stagnant environment, one technique currently implemented on the MSL golf course is spike-aeration” (Wood, 2010). Aeration allows air to penetrate to the soil, minimizing the stagnant condition and kills the snow mold. Snow mold also favors a dark environment, and thatch removal will allow sunlight penetration. “Another preventative measure to avoid snow mold is to remove the snow from the putting greens in the winter. Either the snow can be shoveled or snow blowers can be used” (Lujan, 2010). An alternative would be to apply a lethal fungicide; however, not only is this extremely costly and “overkill,” there were also a lot of side effects including allergic reactions for people, causing illness (Allen, 2010). Although the fungicide works, it makes people sick

and hurts the financial budget due to a decrease in attendance. An article in Golf Digest stated:

“Pesticides pose health risks, both acute and chronic, from common cold like symptoms, nausea, dizziness, headaches, rashes, to birth defects, learning disabilities, infertility, leukemia, various cancers including brain cancer, breast cancer, non- Hodgkin’s lymphoma” (Barton, 2008).

In an effort to ensure the health and safety of their players and the environment and to prevent a decrease in golf activity and attendance, the MSL golf course manager realized a need to implement a policy to inform chemically sensitive golfers prior to applying any form of pesticide or fertilizer application onto the golf course. The policy came in the form of a proactive response from the MSL golf course staff to inform chemically sensitive golfers as part of their IPM procedure, resulting in a more efficient and safer resolution of pest problems. “The chemically sensitive distribution list advises players anytime there is a pesticide or chemical applied on the course” (Lujan, 2010).

Pest issues at the MSL golf course include aphids, snow mold, June bugs, wasps, snakes, mice, dandelions, and other pests which can also create potential hazards to the golfers such as holes in the turfgrass, which can cause injury or spread disease. Currently, obnoxious pests such as mice are trapped and killed monthly. Snakes are also trapped; however, they are not killed but relocated. Although this approach is an alternative to a basic trap-and-kill method and thus avoids any lethal methods, removing the snakes is counterintuitive; removing innocuous predators like the snake can actually be the cause of the increase in the mice population. In David Holmgren’s book *Principles & Pathways Beyond Sustainability*, he explains, “the problem is the solution.” Which means that pests in which IPM or turf managers view as “pests” may be actually be useful to solve the problem. “For instance, weeds or pests may be: Environmental indicators of need for management change, agents repairing damaged soil or resources for economic or cultural reason, we fail to value” (Holmgren, 2002). If perhaps the snakes were left alone they could potentially be a natural IPM strategy for the mice population. Therefore, if the MSL golf course IPM manager would leave the snakes on the course they would actually control the mice population. Utilizing this natural method could result in avoided costs that would

have resulted from the need to trap and relocate the snakes as well as the need to trap-and-kill mice.

Another problem that is directly related to aesthetics is the aphid, which is known to infect the green ash tree. Once the aphid has infected the tree and implants eggs on the leaf, the leaf curls and serves as a protection for the aphid eggs. Not only are the aphids detrimental to the health of the green ash tree, the curly leaves look terrible from a distance. To safely and effectively remove the aphid from the tree it is best to know the life cycle of aphids. It is easier to manage the aphid larvae before the leaf curls up; however, the window of time between laying of the eggs and the leaf curling could be very small. “Typically, the cure for aphids requires high-powered equipment to blast the tree with a pesticide and terminate the pest” (Wood, 2010). However, using poison is not always the solution; a chemically intense method should be avoided and is generally a last resort to a problem. An insecticide that is often used to successfully treat fly larvae is Bt. “Bt is a naturally occurring bacterium common in soils throughout the world. Several strains can infect and kill insects” (Cranshaw, 2008). Unfortunately, aphid larvae are non-susceptible to Bt and require alternative pest management strategies. Although Bt cannot be used to treat aphids on green ash trees, certain strains of Bt have been developed that are successful agents in terminating critters such as chiggers, black flies, and mosquitoes, which are common pests at the MSL golf course. Bt is known to be a safe alternative to synthetic chemicals because “unlike most insecticides, Bt insecticides do not have a broad spectrum of activity, so they do not kill beneficial insects” (Cranshaw, 2008).

Other non-problematic animals are ducks and other birds, which are actually beneficial to MSL golf course as they provide aesthetical value to the ponds and the course. The course provides a natural area for wildlife and attracts cows, coyotes in the early morning, bobcats, and in rare instances, bears. Up to this point these animals have caused no threats to patrons that have caused MSL golf course management to take immediate action.

It is evident that an IPM plan is not a one size fits all approach; for example, there are a lot of different species at MSL golf course that are quite different compared to Mirimichi in Tennessee or Pebble Beach in California and thus requires a custom IPM plan. Due to the uniqueness of the MSL golf course and the rapid advancements in the evolution of IPM it is

easy to understand why there is not a formal comprehensive IPM plan in place. However, when the IPM is developed it is critical that subject matter experts in fields of IPM and turf management make responsible choices that will reduce the potential impacts on the health of the public and the environment.

WATER RESOURCES

“Of all our natural resources water has become the most precious” (Carson, 1962).

According to the Buckman Direct Diversion Project, “Even in the best of years, the Santa Fe River reservoirs can only supply about half of the water our region needs.” Although the MRC uses very little fresh water resources for operations, one major concern for MSL golf course and MRC sports complex is to sustain the flow of their current fresh water supply.

“Mike McCullough, director of environmental and water resources for the Northern California Golf Association in Salinas, Calif., says golf course superintendents and other golf industry leaders better start thinking about the future of their water use or their won’t be a future” (Aylward, 2009).

Two wells currently serve the fresh water supply requirements for the MRC. One well (RGG-66978) serves the restaurant, bathrooms, and administration at the MSL golf course and the other (RG-66978-S) serves the restroom, one concession stand, and the maintenance building at the MRC sports fields. The two wells combined have a domestic well permit of 3 acre-feet per year (afy) and provide fresh drinking and washing water supply for the MRC.

Under the New Mexico Drinking Water Regulations, NMAC 20.7.10.400(M), the MRC is responsible for taking monthly and quarterly bacteriological sampling at MSL golf course and Sports Complex. Under this regulation they must also have a certified operator for all public water systems. The certified operator is responsible to monitor and record chlorine residuals and also total fecal coliform present. Per the records shown, E coli confirmation is always ABSENT, while Chlorine residual ranges between 0.5 and 0.8. Water quality reports must be submitted to the New Mexico Environment Department (NMED) every six

months. R.A.M. Plumbing & Water Services is the company responsible for water quality testing at the MRC sports complex and Links de Santa Fe golf course. Bacteriological water samples are taken monthly and quarterly. This is required under the New Mexico Drinking Water Regulations, NMAC 20.7.10.400 (M).

The MRC under State and Federal regulations must have a certified operator for all public water systems. R.A.M. Plumbing and Water Service is responsible to “monitor and record chlorine residuals” in the dual distribution systems three times per week. As part of the R.A.M. duties, they also collect and submit total fecal coliform samples at the frequency of two per month and/or as required by regulations, which may include collecting and submitting repeat samples. Total fecal coliform samples are required to be submitted to a certified City-approved testing laboratory.

Hall Environmental Analysis Laboratory, Inc is the current company that is responsible for carrying out the water sampling analysis. Samples, which are analyzed and are in compliance with EPA regulations, are documented with this language:

“The samples were analyzed according to EPA procedures or equivalent. ND: Not Detected at the Reporting limit. No Reporting limits are determined by EPA methodology. No determination of compounds below these (denoted by the ND or < sign) has been made.”

The analysis determines concentrations of nitrites (as N) and nitrates (as N)+. If the water samples are not in compliance with EPA regulations, corrective actions must be taken immediately. Corrective action alternatives systems must do one or more of the following: Correct all significant deficiencies, provide an alternative source of water, eliminate the source of contamination, and provide treatment that reliably achieves 99.99 percent (4 log) inactivation and/or removal of viruses.

Although fresh water use at the MRC is minimal, the MRC should take all steps necessary to further reduce fresh water consumption. In effort to further reduce their use of fresh water, the MRC complex installed low-flow toilets in the bathrooms that use 1.6 gallons per flush. Small changes such as these can make a significant difference. The most significant water-wise choice the MRC has made was to utilize reclaimed wastewater for all irrigation needs, thus alleviating the need for significant amounts of freshwater resources.

The MRC uses Class 1B reclaimed wastewater for all irrigation purposes. “Class 1B reclaimed wastewater is the second highest quality reclaimed wastewater and is suitable for uses in which public exposure is likely” (New Mexico Environment Department (NMED), 2007). The NMED defines reclaimed wastewater as domestic wastewater that has been treated to the specified levels. In this case, the MRC uses Class 1B reclaimed wastewater and thus the “specified quality assumes a minimum of conventional secondary wastewater treatment plus disinfection” (New Mexico Environment Department (NMED), 2007). The MRC has considered upgrading to Class 1A reclaimed wastewater to provide water to bathrooms and the like, which would alleviate the demand for fresh water resources and reduce ground water pumping. However, this would require major financial upgrades to the infrastructure, which is not economically sound as there is currently infrastructure in place that provides the rest of the MRC with fresh water. Reclaimed wastewater users are obligated to maintain certain permits and must abide by strict environmental regulations. “The frequency of wastewater quality monitoring is patterned after U.S. Environmental Protection Agency (USEPA) requirements for discharges of treated and disinfected wastewater to surface waters” (New Mexico Environment Department (NMED), 2007). The wastewater quality levels and monitoring frequencies for Class 1B Reclaimed Wastewater are illustrated in Table 2.

Table 2. Wastewater Quality Requirements & Monitoring Frequencies for Class 1B Reclaimed Wastewater

Class of Reclaimed Wastewater	Wastewater Quality Parameter	Wastewater Quality Requirements		Wastewater Monitoring Requirements	
		30-Day Avg.	Max.	Sample Type	Measurement Frequency
Class 1B	BOD₅	30 mg/l	45 mg/l	Minimum of 6-hour composite	3 tests per week for major WWTP ¹ ; 1 test per 2 weeks for minor WWTP
	TSS	30 mg/l	45 mg/l	Minimum of 6-hour composite	3 tests per week for major WWTP ¹ ; 1 test per 2 weeks for minor WWTP
	Fecal Coliform	100 organisms per 100 ml	200 organisms per 100 ml	Grab sample at peak flow	3 tests per week for major WWTP ¹ ; 1 test per week for minor WWTP
	TRC or UV Transmissivity	Monit or Only	Monitor Only	Grab sample or reading at peak flow	Record values at peak hourly flow when Coliform samples are collected

Source: NMED GWQB Guidance: Above Ground Use of Reclaimed Domestic Wastewater – Revision 0.0, January 2007. Under the NMED GWQB, Class 1B reclaimed wastewater users, such as the MSL golf course, must monitor and report findings of the water supply.

There are also very strict rules prohibiting standing water anywhere on the MRC. For example, if there are puddles on the soccer field, along the sidewalks, or anywhere on the MSL golf course, the area must be taken care of immediately

Discharge Permit 289 (DP-289) is required by the NMED to control the discharge/transfer of water from the Wastewater Treatment Plant into the ground and surface water as a means of protection for these waters and for public health. In order to transfer these waters to the MRC, the reclaimed water shall not exceed the following limitations:

Table 3. Limitations for Class 1B Reclaimed Wastewater under DP-289

Test	30-day geometric mean	30-day average	Maximum
Total Nitrogen			10 mg/L
Fecal coliform bacteria	100 Org/100 mL	N/A	200 Org/100 mL
BOD ₅	N/A	30 mg/L	45 mg/L
TSS	N/A	30 mg/L	45 mg/L
Turbidity	N/A	Monitor Only	Monitor Only
UV Transmissivity	N/A	Monitor Only	Monitor Only

This table represents the maximum limitations of nitrogen, fecal coliform bacteria, biological oxygen demand (BOD), total suspended solids (TSS), turbidity, and UV transmissivity. The limitations represent the amount of nutrients that are allowed by the NMED.

Reclaimed wastewater was known to be beneficial to golf courses not only because they avoid the need for freshwater resources, but also because the water was known to be nutrient rich and would typically reduce the need for artificial nutrient supplements. Unfortunately, a recent change by the Environmental Protection Agency (EPA) reduced the maximum limit of ammonia and nitrogen allowed in the treated reclaimed wastewater. This change was critical as these nutrient levels were beneficial to the golf course, which now requires additional artificial nitrogen supplements to be applied to the MSL golf course. This change is more costly not only to the MSL golf course, as there is an additional expense to procure artificial nitrogen supplements as well as incur the additional labor cost to apply the supplement, but also to the City of Santa Fe Waste Water Treatment Facility, as they now have additional processes to meet the EPA requirements.

Although it can be considerably costly to hire certified operators and the like to carry out water quality tests, using reclaimed wastewater is the sustainable choice for the environment as well as for the MSL golf course. The cost for using reclaimed wastewater is also significantly less expensive than for freshwater. However, water costs are currently subsidized by the City of Santa Fe. Moreover, the regulations and requirements to utilize

reclaimed wastewater are often costly and time consuming, but under the current water scarcity conditions and drought status as illustrated in Figure 3, it is in the best interest of the MSL golf course to utilize reclaimed wastewater as it will ensure the viability of the current business operations as well as operate the MSL golf course in an environmentally sustainable manner.

IRRIGATION

Water resource management on golf courses focused specifically on the most water intensive process, turfgrass irrigation, is a very dynamic system. It is far more complex than simply watering the turf daily with an ordinary sprinkler system. In fact, irrigating the MSL golf course entails the use of a very specific watering schedule as well as a highly technical automatic irrigation system. Water resource management requires a well-rounded knowledge of the intricacies that keep turfgrass beautiful, healthy, playable, and durable to meet the golfers needs. For example, each variety of turfgrass requires a specific amount of water. The gradient of the turfgrass should also be considered, as the amount of water must be adjusted to adequately irrigate turfgrass that is located on a slope. Other factors that should be considered is whether or not an area is subject to gusty winds or excessive sunlight.

A minor change in the irrigation system can result in many unintended consequences to the turfgrass and ultimately to the MSL golf course and overall player's experience. For example, a minor adjustment to the irrigation schedule such as changing the time that an area is irrigated or overwatering an area can cause increased fungal growth or invite unwanted pests. Changing irrigation strategies is a technique that can be incorporated in the IPM; for example, overwatering the turfgrass must be avoided to minimize fungus growth. There is another component to be considered, the player aspect, the reason to manage turf in the first place. "Overwatering causes a gamut of difficult management issues that ultimately cost money and degrade playing conditions" (Christiansen, 2010). The MSL golf course must provide golfers with a playable field. Under the NMED Ground Water Quality Bureau Guidance due to the use of reclaimed wastewater to irrigate the course, standing water is prohibited and irrigation cannot take place during periods when

the facility is in use. Therefore, the irrigation cycle must be completed long before golfers begin to play the course and overwatering that can lead to standing water must be avoided. The next component is in attempt to capture the most water and minimize water lost to ET. That means the turfgrass must be watered at a time that will maximize water absorbency and minimize water loss to ET, which is currently accounted for by irrigating early in the morning or late in the evening. Another watering inefficiency that must be addressed to maximize water absorbency is often the result of poorly performing sprinkler heads. Typically, poorly performing sprinkler heads are not addressed appropriately due to budget constraints, lack of time, or the like; however, not replacing the sprinkler head with a better performing sprinkler head and trying to compensate for performance by increasing water times often results in overconsumption of water resources and cumulatively can result in a increased water cost.

The MSL golf course is irrigated using Toro's Site Pro irrigation system. At 100%, a single sprinkler head is designed to give out 65 gallons per minute (gpm) at two – ten-minute cycles - meaning that in order to reduce run-off and as a means to increase efficiency, the sprinkler system is set to cycle two different times for ten-minute intervals each time. There are three sprinkler heads per valve; in total there are 44 valves on the driving range and 132 sprinkler heads, 19 satellite stations with approximately 732 valves, totaling 2,196 sprinkler heads. There is a grand total of 2,328 sprinkler heads. The following is a hypothetical calculation if the system was operating at 100%: 151,320 gallons per one minute or 3,026,400 gallons per 20 minutes. This is not an average water use as the MRC uses about 800,000 to 1 million gallons of water per day. Therefore, by accurately calibrating the irrigation system to account for ET, precipitation, wind factors, etc., at least 2 million gallons of water are conserved and the City saves a significant amount of money. "A superintendent must preserve water resources, as there is no agronomic or economic benefit to a golf course manager who overwaters his site" (Christiansen, 2010). Enabling staff to make more precise, accurate watering decisions by providing them with essential tools such as in-ground moisture sensors or on-site ET towers can further reduce water consumption and increase watering efficiency. Another method to conserve water, yet adequately provide sufficient water, is to increase the amount of sprinklers and decrease the amount of water consumed; this occurs by having the ability to have more control of where

and when the water is applied (Christiansen, 2010). Not only does conserving water reduce cost for the MSL golf course in many ways such as time and labor avoided by eliminating overwatering and run-off, but it also saves taxpayer dollars as the MSL golf course water budget is subsidized by the City of Santa Fe. These financial savings do not include the embedded cost for reducing the amount of wastewater that must be treated nor do they include the energy savings of reducing the demand for reclaimed wastewater. “The effects of global warming are beginning to be seen and most predictions indicate that climate in Santa Fe will become hotter and drier” (Sustainable Santa Fe Commission Team, 2009). In the future, it is possible that the demand for reclaimed wastewater by other priority users, such as agriculture or industry, will cause a decrease in the amount of water that is allocated to the MSL golf course. As a measure of precaution, it is imperative that the MSL golf course make significant efforts to further reduce water consumption and increase water efficiency to sustain the playability of the course.

The MRC is irrigated using 100% class 1B reclaimed wastewater from the City of Santa Fe Waste Water Treatment Plant. The Waste Water Treatment Plant allocates 2 million gallons of water per day to the MRC. The golf course has since it opened used reclaimed wastewater for turfgrass irrigation as this was planned into the developmental stages of the course. The daily average water usage at the golf course ranges between 800,000 to 1,000,000 gallons of water. The sports fields use roughly 66% less water than the golf course, with average daily water usage ranging between 250,000 to 300,000 gallons. It is important to note that the daily average consumption varies with temperature, precipitation, and sunlight intensity (i.e., ET rates).

The irrigation schedule is as follows: it begins at 8:40 pm every evening and concludes between 5:30 am and 6:00 am, 7 days a week; this is in compliance with NMED Ground Water Quality Bureau Guidance as irrigation is required during the periods when the facility is not in use. The MSL golf course currently waters in the evening or early morning hours, which is an excellent strategy to increase water efficiency and reduce excessive ET. The irrigation process is currently operated using an automated remote satellite systems; more specifically called Site Pro by Toro, as previously mentioned. In July the controllers are set at 100%. The calculation is as follows:

ET Rate x Amount of water the grass needs = maximum amount of water given.

The golf course only pays pumping fees. The water is pumped into the MRC Links de Santa Fe and the Sports complex using electric pumps. The total water usage is subsidized by the City of Santa Fe; however, if a cost were imposed the golf course would be responsible for paying the current rate of \$3.00 per 1000 gallons of water. As the course and sports complex use 1,000,000 and 300,000 respectively on daily average, the MRC would be charged (1,300,000 x \$3.00/1000 gallons = \$3,900 per day or \$117,000 per month based on a 30-day calendar month).

The pump house is located on the MRC, near the Great 28 playing course, and is basically the circulatory system of the golf course. It pumps life-giving water onto the course. The pump house tracks the amount of water that is pumped into the 3-million-gallon pond from the Waste Water Treatment Plant and also tracks the amount of water pumped out onto the golf course. The pump house also monitors nitrogen and other chemical levels. The total water usage and chemical levels are recorded daily. The MRC is required to submit a report to the New Mexico Environment Department (NMED) every six months. If the fecal count is higher than the regulatory limit, the MRC is not permitted to pump water; fortunately, this is a rare occasion as it would be detrimental to the turfgrass. Fecal limits have to be below 23 fecal coliform. Utilizing reclaimed wastewater to irrigate the 90-acre golf course not only avoids the use of fresh water consumed, but it is also less expensive than fresh water.

Weather permitting, the golf course is open on occasional days during the winter months. During the winter months the water is shut off and the lines are drained to prevent freezing. The sports complex is also closed in the winter months, beginning on November 1st and reopens during mid April or May. The irrigation lines at the golf course and sports complex are winterized to avoid frozen pipes. A water truck is used to irrigate the fields or the course if necessary in the winter months when the water lines are turned off.

The City of Santa Fe has a drought plan in place, which is as follows: Stage 1 is low restriction. Stage 2 requires even-odd day of watering. Stage 3 restricts watering to once or twice a week. The MRC is not governed by the same policies because the golf course

uses reclaimed wastewater water. When the “drought plan” is put into effect, the city is restricted to water less frequently and the MRC is indirectly impacted, as there is less water available to be treated at the Waste Water Treatment Plant. There are four entities vying for reclaimed wastewater: Las Campanas Golf Courses (two 18-hole golf courses), Santa Fe Country Club (one 18-hole golf course), the Santa Fe Polo grounds (horse park), and Marty Sanchez Links de Santa Fe Golf Course and Sports Complex (one 18 hole golf course, plus a mini-course par 3). However, there is no quota or limit to how much water the MRC is entitled to. There is no priority as to who gets the water first. Reclaimed water comes from plant to MRC and then to the Caja del Rio landfill to keep the dust down, next it is transferred to a rancher to who uses the water for irrigation purposes as a means to feed his cows. The water in the ponds cannot drop below a certain level or algae will begin to grow. If the water is too low the MRC can request more water; this is a cooperative agreement and relationship. As a water conservation measure, there is default rain delay setting that will disable the irrigation system from cycling. Baxter Spann designed the MSL golf course with drains located in low gradient areas that captures run-off from overwatering or during rainfall. This is great approach to harvesting water.

The following parameters are often considered when developing an irrigation plan: climatic condition, temperature, rainfall, and length of growing season, sunlight intensity, and the species of turfgrass. The following irrigation water management and control methods are employed on a daily basis:

- a. The turfgrass and/or soil moisture is inspected to aid in scheduling decisions. If the turfgrass were on the dry side, the system could pump up to 1.6 million gallons if necessary.
- b. The short-term weather forecast is a necessity and aids in the irrigation schedule.
- c. ET data from the local weather service is often a consideration, but it is not as accurate as needed for the MSL golf course.
- d. The onsite ET weather station is not currently used due to technical difficulties, but there are plans to fix the station. Although the station is not currently functioning properly, the MSL golf course could use historical ET data. For

example: July would be the highest ET month and thus the turfgrass requires a ¼ inch of water per day in July. This can be determined for every month and can assist in the scheduling decisions.

- e. Other factors that are considered are the wind speed, which can further increase ET.
- f. Most often scheduling requires improvisation and adaptation.

One opportunity to conserve more water or rather reduce the amount of water lost to ET would be to increase the depth of the ponds. A deeper pond is more efficient versus a shallower pond as the surface area of a deeper pond is often smaller and thus leads to a reduction in evaporation. Another opportunity is in regards to the infrastructure. In the future, when the pipes need to be replaced, the pipes should be replaced with a larger, more efficient pipe. The current pipes are thought to be too small and cause an increase in pumping charges.

TURFGRASS MANAGEMENT

TURFGRASS

“In the U.S., there are an estimated 50 million acres of turf. Only 3% of the turf in the U.S. is managed as the nation’s 17,000 golf courses” (King & Balogh, 2006). Ornamental turfgrass has acquired a bad reputation with conservationists and has negative connotations associated with it, especially when its primary use is to irrigate golf courses in desert regions such as NM. Turfgrass is considered to be extremely water intensive and a poor use of fresh water resources. “But well-managed lawns are an environmental asset. They can help protect or even improve water quality and control erosion” (Frank Rossi, 2005).

The MRC has over 90 acres of irrigated turfgrass and landscaping. Selecting the appropriate turfgrass for a golf course can be difficult as there are many components that should be considered. Critical components include the adaptability of the turf to NM climate and diurnal temperatures, the growing cycle of the turfgrass, and the recuperative ability. The turfgrass varieties at the MSL golf course differs on the greens, fairways, tees, and roughs; turfgrass varieties are selected according to the desired playability and

recuperative ability as well as the maintenance requirements. Certain turfgrasses are often selected for a certain playing fields, such as Bentgrass on the greens and Kentucky bluegrass on the roughs and tees. The MSL golf courses has several varieties of turfgrass; site specific turfgrass reduces maintenance costs and pest problems and conserves water as some turfgrass require more care than others. For example, Las Campanas private golf course is entirely composed of Bentgrass, which consumes more water to maintain a quality playing condition, whereas MSL golf course has Bentgrass only on the greens. This is an example of monoculture versus polyculture. Monocultures such as Las Campanas private golf course are more susceptible to disease, not to mention the already needy requirements to properly manage Bentgrass. Alternatively, the MSL golf course, which has a variety of turfgrasses, is less susceptible to disease. Holmgren states in his book *Principles and Pathways beyond Sustainability*, “A diversity of crop varieties and species provides some degree of security for insurance against season failures and pest or disease attack” (Holmgren, 2002).

The turfgrass on the MSL golf course putting greens is Penn Links Bentgrass. The high density of the needles allows for higher speed, increasing the difficulty of the play and increasing the challenge level for the golfer.

The fairways consist of an equal mixture of Kentucky bluegrass (33%), Red Fescue (33%), and Perennial Ryegrass (33%) (Allen, 2010). These are all categorized as cool-season grasses, which are known to require more water than warm-season grasses. Cool-season grasses grow best during the spring and fall season when the temperature is cool and there is an adequate amount of moisture. These climatic requirements are nearly perfect for Santa Fe, NM and furthermore for the MSL golf course, as the average temperatures in the spring and fall are cool and there is typically an adequate amount of run-off in the spring and monsoon rains in the fall. “Optimum growth of [cool-season] grasses occurs with a temperature range from 60 to 70°F” (15.5 to 21.1°C) (Leinauer & Baltensperger, *Turfgrass for New Mexico: Guide H-508*, 2002). In general warm-season grasses seem to be the most appropriate choice for turfgrass in NM; however, the differentiation in daily temperature as well as seasonal changes and the high altitude make the choice of turfgrass

for NM more complex. The seasonal and daily diurnal cycles are illustrated in Figure 1 and 2.

“But low temperatures, due to high elevations, particularly in the winter, make cool-season grasses the better choice. Because of the cool fall, winter, spring and relatively cool summer night, cool-season grasses can be grown successfully almost anywhere in NM under regular irrigation conditions” (Leinauer & Baltensperger, Turfgrass for New Mexico: Guide H-508, 2002).

Although NM provides suitable growing conditions for cool-season grasses, the turf selected must be durable and healthy to endure a NM summer. “If planted in areas likely to have prolonged periods of high temperatures or drought (as in much of New Mexico), cool-season grasses will require plenty of moisture during times of stress” (Goldberg, 2000). Summer stress often results in dollar spot, brown patch, leaf spot and other turfgrass diseases. The turfgrass must stand strong against the unfavorable conditions of Mother Nature, increased temperatures, strong winds, and lack of precipitation. “Roots can be damaged when temperatures are above 85°F (29.4°C). During the “summer slump,” warm-season weeds such as crabgrass (*Digitaria* spp.) thrive because they are more competitive in warm weather” (Frank Rossi, 2005). After the “summer slump” growth will continue until the ground freezes.

Table 4. Turfgrasses for New Mexico

Grasses	Grass type	Growing areas in New Mexico	Traffic tolerance	Recupertive capability
Bentgrass	C	N,S	Low	High
Bermudagrass	W	S	High	High
Blue Grama	W	S	Low	Low
Buffalograss	W	N,S	Medium	Low
Fine Fescue	C	N,S	Medium	Medium
Kentucky Bluegrass	C	N	Medium/High	Medium
Perennial Ryegrass	C	N,S	High	High
St. Augustinegrass	W	S	Low	Low
Tall Fescue	C	N,S	High	Medium
Zoysiagrass	W	N,S	High	Low

Source: (Leinauer & Baltensperger, Turfgrass for New Mexico: Guide H-508, 2002) *C: cool-season grass, W: warm-season grass, N: north, S: south. The above table is a list of recommended turfgrasses for New Mexico. Recommendations include both cool-season and warm-season grasses, which is a result of the variations in NM elevations as well as southern and northern regions.

Using Table 4. Turfgrasses for New Mexico as a guide to choose the proper turfgrass, Kentucky bluegrass (*Poa*) is an excellent choice of turfgrass for the MSL golf course. Kentucky bluegrass is a long-lived perennial, cool-season grass that grows well in northern New Mexico (Santa Fe is in northern New Mexico). The turf has a medium to high tolerance for traffic and is well known for its ability to recovery rapidly. “The bluegrasses are adapted to seasonally cool upland climates and are tolerant of wide diurnal and seasonal fluctuations in both temperature and available moisture” (Pennucci & Langille, 2007). The adaptability of bluegrass is important as Santa Fe experiences diurnal and seasonal fluctuations due to the high altitude, this is illustrated in Figure 1 and 2.

“Kentucky bluegrass is frequently used in seed mixtures with perennial ryegrass and/or fine fescue. The more rapid germination of the perennial ryegrass or fine fescues acts as a “nurse crop” to provide soil stability during the slower germination of the bluegrass yet they do not compete for nutrients and water during establishment” (Pennucci & Langille, 2007).

Perennial ryegrass, which comprises one-third of the MSL fairway turfgrass mixture, “is one the most widely used grasses and is adaptable to a wide variety of soils and climatic conditions” (Oregon Ryegrass Growers Seed Commission, 1999). According to New Mexico State University guide to choosing turfgrass, the Perennial Rye grass is also an excellent choice for the MSL golf course as the conditions for successful growth are favorable in Santa Fe. Perennial Rye is also a cool-season grass that grows well in northern and southern NM and has a high traffic tolerance and a high recuperative ability. These qualities are necessary especially to endure the climate as well as provide the resilience needed to withstand the traffic on the golf course. “In northern regions the turf-type Perennial Ryegrasses are used for permanent turf on virtually every area of the golf course including fairways, roughs, tees and greens” (Oregon Ryegrass Growers Seed Commission, 1999).

Although it is not listed in Table 4, Red fescue is also a cool-season grass that is hardy and wear-resistant and drought resistant.

MOWING SCHEDULE

“Mowing is one of the most important cultural management practices in caring for lawns” (Goldberg, 2000). It is also one of the most labor-intensive and time-consuming duty at the MSL golf course. To maintain a desirable and uniform playing surface that is required of golf, the turfgrass should be mowed with a certain frequency and to a certain height to maintain the desired playability. The height of the grass can greatly impact how the golf ball rests on the turfgrass and the overall golf experience.

For example, “At heights above 1 inch, the golf ball tends to settle into the turf canopy. But the turf is not dense enough to support the golf ball completely above the canopy. At heights below an inch, the golf ball sits up because of the increase in the number of shoots supporting the ball” (Danneberger, 2009).

However, mowing practices should also consider the appropriate height suitable to maintain healthy turfgrass. As a result certain mowing frequencies and heights can increase the time needed to properly manage the turfgrass as well as increase the susceptibility of the turfgrass to disease and pests. “Mowing affects turf density, weed infestation, water

consumption, and susceptibility to environmental stresses” (Leinauer, Mowing Your Lawn: Guide H-505, 2010).

In general, golf courses require putting greens to have the shortest mowing heights, and then there are slight increases in mowing heights from the greens outward to the fairways and roughs. “For many, increasing heights of cut, especially on putting greens, may not be an option. But for those who can raise the height of cut to a more optimum height, the cost of maintaining that turfgrass is likely to decrease” (Danneberger, 2009).

The putting greens, composed of Penn Links Bentgrass, are typically cut the shortest of all the playing areas. The current mowing schedule for the greens consists of mowing five days per week, to the average height of .109 inch or 7/64 inch. The short length creates a denser and faster playing surface, which allows the golf ball to move more quickly and increases the challenge level in this area.

“The effects of closer mowing include increased shoot density but decreased root growth. The shallower root system requires more frequent irrigation and fertilization to compensate for the turf’s reduced ability to secure moisture and nutrients from the soil” (Leinauer, Mowing Your Lawn: Guide H-505, 2010).

In an effort to maintain the health of the Penn Links Bentgrass in the putting green, the grass is rolled two days per week. Rolling the greens rather than mowing the greens maintains the green-speed and also gives the turfgrass time to recuperate by allowing the grass to grow, which promotes a healthy root system.

The fairways and tees are on the same mowing schedule and are typically cut to the same length, resulting in matching grass heights. Tees are composed of Kentucky bluegrass and the fairways are composed of equal parts Kentucky bluegrass, Perennial Rye, and Red Fescue. The tees and fairways are mowed two days per week and are normally cut to ½ inch to ¾ inch length. “Turf-type Perennial Ryegrasses have shown the ability to thrive at any height ranging from 3/16 inch on putting greens or up to 1 ½ inches for other uses” (Oregon Ryegrass Growers Seed Commission, 1999). “Kentucky bluegrass mowing heights ranging from 0.75 to 2.5 in., with optimum heights of 1.0 to 1.5 in. Mowing frequency will play a critical role in stimulating both rhizome and root growth; frequencies

of one to three times weekly will be required” (Pennucci & Langille, 2007). The mowing height of the fairway turfgrass has been increased to 9/16 inch to alleviate intensive grooming requirements and to maximize playability. “A common practice is to raise the mowing height during periods of increased environmental stresses, such as heat and drought stress in the summer and cold temperature stress in the winter” (Leinauer, Mowing Your Lawn: Guide H-505, 2010). The turfgrass is responding to this height well, it is aesthetically pleasing, and it is easier to maintain; however, it is not responding well in high temperatures, especially on humps and hills as the wind and sun are more abrasive in these regions as well as the issue with water running off to the lower grass surfaces. Since a uniform mowing height is desired, altering the mowing heights on the humps and hills is not an acceptable practice; therefore, it is recommended to address this issue during irrigation rather than during mowing. A simple solution would be to give the humps and hills an adequate amount of water to combat wind and sunlight. Since run-off is the current problem it is necessary to water with less water and more often. For example, water the humps and hills twice per day for less amount of time.

The roughs, composed of Kentucky bluegrass, are also cut twice per week to 2¼ inch. The mowing length as previously cited by Pennucci and Langille is within the optimal growth requirements and is therefore beneficial to the overall health of the turf.

A common practice at the MSL golf course is to utilize nutrient-rich grass clippings, which are typically high in nitrogen and chlorophyll. When turfgrass is mowed frequently, which is the case for MSL golf course putting greens, the grass clippings can be reused and treated as a nutrient supplement. The clippings are typically spread into the natural areas or placed on the fairways for thatch as a natural fertilizer supplement.

“When turf is mowed frequently, clippings contain 90% water and therefore do not contribute to thatch accumulation. Clippings also consist of approximately 4% nitrogen, 0.5 to 1% phosphorous, and approximately 2% potassium, as well as essential micronutrients” (Leinauer, Mowing Your Lawn: Guide H-505, 2010).

This has significant dollar savings as artificial nitrogen and chlorophyll would have to be purchased if the grass clippings were disposed. The frequency the grass would need to be supplemented with nitrogen or chlorophyll would also require labor and thus require

additional funding. “Grass clippings returned to the lawn can reduce fertilizer use by 25%” (Leinauer, Mowing Your Lawn: Guide H-505, 2010).

Selecting the proper mowing heights is crucial to the overall health and playability of the turfgrass; however, another component that need not be overlooked is the quality of the mowing job. “The key to a quality mowing job is a sharp blade” (Leinauer, Mowing Your Lawn: Guide H-505, 2010). “Dull mower blades will leave jagged cuts, which will be more susceptible to diseases than smooth, clean cuts, and will leave a tattered appearance in the lawn” (Goldberg, 2000). A dull blade can also increase the energy needed to mow the turfgrass and indirectly cause an increase in unwanted pests. Turf managers should always check the blade before mowing the turfgrass.

For example, the roughs and tees are both Kentucky bluegrass; however, the tees are mowed shorter than the roughs and due to the shorter length, the tees require more water to sustain maximum health and playability and to compensate for water lost to ET.

FERTILIZER

As previously mentioned in the IPM section, the City of Santa Fe IPM manager is required to approve any type of chemical used on the course; however, approval from the IPM manager is not required for the application of fertilizers or top dressing as these are organic materials. The MRC uses the least amount of fertilizers possible, and typically when turfgrass is healthy and strong there is less of a need to apply supplements. The putting greens are fertilized four times annually; the first fertilization takes place in the early spring, then again before spring aeration. “Applying fertilizer in the spring is helpful to re-establish turf that has been dormant during the winter” (Goldberg, 2000). Another half rate is applied in June and August, and a full rate is applied during the fall (September or October) as the temperature cools down.

“However, a good general recommendation is to apply 50% or more of the total yearly nitrogen in the fall. During this time cool-season grasses produce most of their tillers, which creates a thicker lawn” (Goldberg, 2000).

The fertilizer consists of a blend of nitrogen, potassium, and phosphorus. The half rate fertilizations are given because if the temperatures are high, too much nitrogen could burn the turfgrass. The fairways need about 4 lbs of nitrogen per acre per year, and the tees get the same nutrient supplement as the fairway, sometimes about 5 lbs. The application of fertilizers must be done with specific wind conditions of less than 3-4 miles per hour due to the small granule size. The fertilizers are a granular application, dispersed via spreaders. A broadcast spreader is used for the fairways and tees (tees are more high traffic than fairways), and the greens are fertilized using a walk behind spreader. The MRC uses a fertilizer named 1688, which consists of 16% nitrogen, 8% potassium, and 8% phosphorus. An organic fertilizer named Biofalm is used on the driving range; unfortunately, the odor is extremely foul for several days after the application (Allen, 2010). In effort to counteract and eliminate this foul odor, the pH could be adjusted as necessary.

The current fertilizer schedule for the MRC is tabulated in Table 5. The total irrigated acres for the MSL golf course is 90 acres.

Table 5: MSL Golf Course Fertilization Schedule

Date	Fertilizer Type	Location	Per Acre (LBS)
February-10	14-3-3 Fung. II	Front 9 Grns.	8 @ 40
February-10	14-3-3 Fung. II	Back 9 Grns.	9 @ 40
February-10	14-3-3 Fung. II	Par 3 Grns.	7 @ 40
April-10	17-0-17	Front 9 Grns.	8 @ 40
April-10	17-0-17	Back 9 Grns.	9 @ 40
April-10	17-0-17	Par 3 Grns.	7 @ 40
June-10	16-6-8 w/trimec	Front 9 Fairways	40 @ 40
June-10	16/6/8 w/trimec	Back 9 Fairways	50 @ 40
June-10	21 - 7 - 14 / 4% iron	Front 9 Fairways	53 @ 50
June-10	21 - 7 - 14 / 4% iron	Back 9 Fairways	54 @ 50
July	Organic 5-6-5	Golf Course	0.5
August	Organic 5-6-5	Golf Course	0.5
September-10	Scotts Greens. 17/3/17	Golf Course Front 9	6 @ 50
September-10	Scotts Greens. 17/3/17	Golf Course Back 9	7 @ 50
September-10	Scotts Greens. 17/3/17	3 Practice Greens	3 @ 50
September-10	Scotts Greens. 17/3/17	Great 28	5 @ 50
October 8 - 10	FWY. 15/3/9	Golf Course Back 9	199 @ 50
October 8 - 10	FWY. 15/3/9	Golf Course Front 9	195 @ 50
October-10	FWY. 15/3/9	Driving Range	31 @ 50
October-10	FWY. 15/3/9	Great 28	76 @ 50

Source: (Richardson, 2010)

For Kentucky bluegrass, “the recommended annual nitrogen budget is 2 to 6 lbs. of nitrogen per 1,000 ft² per year; higher levels and more frequent applications will be required if clippings are routinely removed. “Kentucky bluegrass responds best to applications of slow-release materials; it can be easily maintained with 100% slow-release sources if the turf manager is adroit at predicting the seasonal fluctuations in growth and development” (Pennucci & Langille, 2007). Perennial rye requires “an annual application of 3-5 lbs. of nitrogen per 1,000 square feet and is most effective when applied in equal parts in the spring and fall” (Oregon Ryegrass Growers Seed Commission, 1999).

Topsoil application does not require permission. However, the MRC does not typically use much topsoil unless it is for landscaping purposes. Topsoil dressing was mostly used during the grow-in stages. The MSL golf course does use a lot of sand for top dressing, especially after aeration for greens and tee boxes.

Erosion is not currently a major problem at the MRC. However, during the initial construction phases of the MSL golf course, the turf was seed grown and there were occasional problems with erosion. To reduce erosion on the landscape during grow-in and in the present, hay bales along with a custom hand-watering irrigation scheme are used in problematic areas.

Due to the strict EPA guidelines surrounding the use of reclaimed wastewater water, there is virtually zero run-off at the MRC. There are federal guidelines, “Reclaimed wastewater waste water EPA guidelines,” and there cannot be any standing water anywhere, because it can go septic immediately. The EPA guideline not only protects the health of the golf players, it inadvertently prevents erosion, which often occurs as a result of run-off and it also protects stream water and river water that could potentially be the end point for the run-off from the MSL golf course.

SOIL

The health of the soil on a golf course directly impacts the water efficiency as well as the prosperity and health of the turf grass. Unfortunately, there was not a recent soil survey for the MSL golf course and thus it is highly recommended to have a comprehensive soil analysis. The analysis will allow turf managers to better care for their turf as amendments can be made to make up for soil deficiencies. Golf courses are good reservoirs for soil as they reduce erosion and keep the soil in place. The MSL golf course has sandy loam soil. The chemical properties of soil strongly influence turfgrass health; if a soil is too alkaline or acidic it can cause the plant severe stress or even mortality. Plants generally grow best under neutral pH levels; however, soil amendments can be made to increase or decrease the pH of the soil. “Much of the soil in New Mexico is on the alkaline side of the scale (high pH), so the pH needs to be lowered. Sulfur is probably the most common amendment for lowering soil pH” (Goldberg, 2000). The permeability also strongly influences the health

of the turfgrass as it can constrict the amount of water the plant receives. Tight soil can also cause severe run-off, and often times turf managers address this problem by increasing the amount of water the area receives. Another strategy is to aerate the soil and increase permeability and drainage properties. Ultimately it is best to prepare the soil of a golf course in the developmental stages. It is more difficult to mend soil properties when the turfgrass is already in place.

“If the topsoil is sandy or light, it can produce excellent putting surfaces while requiring less water and fertilizers than the modified soil or USGA type greens. The downside is that if there is too much silt or clay in the topsoil, it has the tendency to compact and limit oxygen to the grass root zone. To combat this compaction, the green maintenance staff must punch holes in the soil (aerate) four to six times per year to let oxygen move into the soil.” (Hurdzan, 2005)

Soil often takes on the properties of the water that is used to irrigate the course; since the MSL golf course is irrigated using reclaimed wastewater, there is often an increase in salinity levels, which can cause stress to turf (which is low tolerant of salt).

One typical problem at the MRC is inconsistent soil properties in various locations around the course (Allen, 2010). A soil test is recommended and a full water quality test that would include bicarbonates, calcium, sodium absorption ratio, pH. Soil amendments are currently used where needed, including humates and pre-emergents for the dandelions.

ENERGY MANAGEMENT

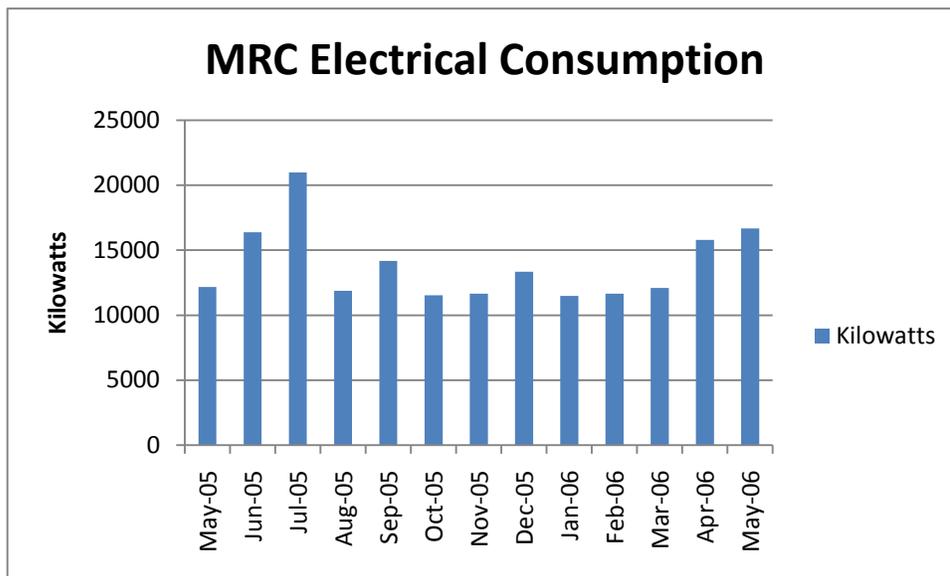
The largest energy consumers of the golf course include the recharging of the golf cart batteries, cooling and lighting of the buildings, and cooking and dish washing in the restaurant. The cost of utilities, gas and electric, is divided 40/40/20 respectively between the Pro Shop, restaurant, and MRC administration building. Currently, the electricity usage for all three areas is monitored solely in the restaurant; however, plans to implement site by site monitoring are being considered to gather a more accurate reading and utility billing for each consumer. Table 6 below is an example of the electrical consumption at the MRC from June 2009 to June 2010.

Table 6. MRC Electrical Consumption

Month	Kilowatts
Jun. 2009	12160
Jul. 2009	16368
Aug. 2009	20984
Sept. 2009	11872
Oct. 2009	14176
Nov. 2009	11536
Dec. 2009	11648
Jan. 2010	13337
Feb. 2010	11484
Mar. 2010	11644
Apr. 2010	12085
May. 2010	15781
Jun. 2010	16660

This table represents the monthly total electrical consumption in kilowatts for the MSL golf course, which includes the Back 9 Grill restaurant, Pro Shop, administration building, and maintenance shops as well as for the sports facility. The information was derived via monthly electrical bills provided by the MSL golf course Information Coordinator, Jennifer Richardson.

Figure 5. MRC Electrical Consumption



Source: MSL Golf Course Information Coordinator, Jennifer Richardson. This figure illustrates the monthly electrical usage in kilowatts from June 2009 to June 2010. Although it is not clear in this graph, if the data were set up from January to December rather than June to June, the consumption would make a bell shape, which illustrates that electrical consumption is highest in the summer months, which is expected as this when the MSL golf course is fully operating.

There are various opportunities to continually conserve energy at the MSL golf course. Energy savings typically result in a cost savings. Conserving energy also results in water conservation. City of Santa Fe Energy Manager stated, “Every kilowatt hour uses ½ gallon of water” (Schiavo, 2010). Therefore, every kilowatt hour saved reduces water consumption.

One of the highest energy consumers is the energy used to process the reclaimed wastewater and then to pump the treated water to the MRC. However, this is an embedded energy cost of the MRC water usage. The MRC currently pumps water into the pond daily at 11 am. Keep in mind that peak hours for electricity usages are between 8 am and 8 pm, Monday thru Friday. One opportunity to save money is to pump water during off-peak hours, when the energy demand is at a minimum, thus pumping water between 8 pm and 8 am, Monday thru Friday. Saturday and Sunday are also considered off-peak. This must be

coordinated accordingly as the MRC begins irrigating every night at 8:40 pm and ends between 5:30 am and 6:00 am, seven days a week. Another opportunity to conserve water while pumping water is to purchase a more energy efficient water pump when the current pump is no longer functioning.

The highest and quickest return on investment (ROI) would be to focus on retrofitting lights. On average, a typical ROI would be within 3-5 years. For example, if the MRC invested \$10K, the MRC would see the return in electricity in 3-5 years. However, an alternative approach to conserve energy with minimal investment can be implemented in areas such as the Pro Shop, administrative building, and the Back 9 Grill restaurant. The simplest way is to maximize daylight to reduce costs and simply changing the paint color to a brighter more light reflective color can do this. It is interesting to note the Back 9 Grill restaurant has several promo type lights that are on during the daytime, which could be an avenue to conserve energy.

The next opportunity to conserve energy is by replacing the current water heater with a tank-less, instantaneous on-demand water heater. This would be beneficial for bathroom sinks that require only minimal amounts of warm water for hand washing.

If electrical appliances are older than ten years, they should be replaced with a newer energy-efficient model. There is currently a walk-in freezer stationed outside the MRC restaurant. There is absolutely no insulation around the unit. It is highly recommended to insulate the unit with R50 insulation to keep the unit cold and reduce the amount of energy required to keep the unit cool. A ROI study should be conducted to better understand if it would be more beneficial to replace the entire unit with a new energy-efficient unit.

LED street lights use half the power of high-pressure sodium lights. However, the light is not as bright as the current bulbs, which are necessary for the sports field. These can be considered for the parking lots or areas that are purely aesthetic.

A major investment in energy conservation would be the installation of solar panels to supply energy for MRC use. Unfortunately, the City does not qualify for any federal tax credits because the City does not pay taxes. This could be to the City's advantage: if the solar panels generate an excess amount of energy the utility company must allow you to

sell the extra electricity. Solar is the best alternative energy source for NM, but due to the location of the MRC, security of the panels needs to be considered, as theft could be a possibility. Columbia Par Car is an alternative for the current golf carts. These cars have PV panels and would not require an alternative electricity source.

Encouraging employees to be more energy conscious is a great way to conserve energy. Employees can be encouraged to turn off computers and lights at the end of the day and over weekends and holidays. Also older CRT monitors can be replaced with more energy-efficient LED monitors.

WASTE MANAGEMENT

The MSL golf course has conventional waste management practices. The solid waste from the kitchen, Back 9 Grill restaurant, Pro Shop, and administration building as well as around the course and in the rest rooms is consolidated and picked up weekly. The waste is then discarded into the Caja del Rio landfill. Recycle bins are not readily available on the course or in the restaurant for patron use; this could be attributed to lack of staff available for waste management. However, there are recycle bins at the cart barns and in the kitchen. All trash left in the carts by patrons is separated into recycle bins (bottles, paper, plastic, etc.). There are also recycle bins available for the restaurant staff in the back of the kitchen.

The MRC currently pays a monthly service charge of \$69.15 and an additional \$8.00 dollars to rent each refuse bin. Although these charges are minimal, a percentage of these costs could be avoided by increasing recycling at the MRC. Not only does the City of Santa Fe benefit financially by recycling, this also diverts waste from the landfill, which prolongs the lifetime of the landfill, which is also currently operated by the City of Santa Fe. As there are not currently recycle bins available for patron use, providing recycle bins in common areas such as on the course or in the restaurant will capture a higher quantity of recyclables. This approach would also avoid the need to assign staff to segregate recyclable material. These recycle bins should be placed near the waste receptacles with visible and proper signage. On the bin itself there could be a catchy message such as the amount of waste diverted from the landfill or how much energy or water is conserved by

recycling. In addition to collecting the recyclable material at the Cart shop and in attempt to increase recycling and divert waste from the landfill, proper signage in the golf cart and around the course can increase the amount of recyclables collected. Although the MRC currently has recycling as part of the waste management plant, the Solid Waste department does not track individual waste weights for the MRC, but rather tracks only for the entire City of Santa Fe as a whole. Although the environmental benefit is clear to see, the lack of recycle weights makes it difficult to calculate the financial benefit of recycling.

METHODOLOGY

A baseline was established by conducting an assessment of the current environmental resource management practices in place at the MSL golf course. The areas of focus were water management and IPM strategies; however, energy management, turfgrass management, waste management, and land development were also assessed. The site analysis was conducted via numerous site visits to the MSL golf course as well as in person interviews with the MSL golf course manager, superintendents, turf manager, and information coordinator. Interviews conducted were often touring the MSL golf course to better observe current operations, strategies, and problems. The City of Santa Fe provided significant amounts of data pertinent to MSL golf course operations including water consumption records, fertilization records, and electricity and gas consumption.

Secondly, a critical literature review of water management and IPM strategies was also conducted to provide opportunities for water conservation and pollution prevention of IPM at MSL golf course.

RECOMMENDATIONS

The MRC is already home to many birds, fish, insects, and animals; however, in order to increase the player experience as well as an initiative to provide a sanctuary or refuge for wildlife, it would be beneficial to continue to accommodate the current animals as well as introduce methods that would welcome new wildlife to the MRC. For example, to attract

hummingbirds, native flowers can be planted that would attract hummingbirds. An artificial method could be to introduce hummingbird feeders.

It is highly recommended to promote and be recognized for environmental stewardship on the golf course. One of the easiest ways to promote environmental initiatives is to apply for an award. There are several awards that are specific to environmental stewardship on golf courses, including the Audobon International and Groundwater Guardian Green Site. The Groundwater Guardian Green Site is no-cost award designated by The Groundwater Foundation who “recognizes good stewards of groundwater by encouraging managers of highly managed green spaces to implement, measure and document their groundwater friendly practices” (Walsh, 2010). The City of Santa Fe and the State of New Mexico offer several award programs to promote environmental stewardship and pollution prevention. Awards systems that are available in New Mexico include Green Zia and Keep Santa Fe Beautiful.

In the event that financial resources are cut short, the face of MSL golf course may change significantly. Golf courses around the world are already changing the face of golf from the intensely groomed course that most are familiar with to a more shaggy looking course that requires less maintenance and often times less water. “The hot courses are not dutiful apostles of Augusta; they are unique, wild and woolly-looking layouts like Bandon Dunes, Sand Hills, Chambers Bay. Americans increasingly love to visit the rugged, natural links of the British Isles, where the game began” (Barton, 2008). The MSL golf course already has some “wild and woolly-looking layouts” in the perimeter of the golf course where it is exploding with native plants, shrubs, flowers, and trees. These areas require little to no maintenance and zero water input. If push comes to shove, the MSL golf course could implement a more natural playing area. Over-conditioning or intensive grooming is unnecessary. “Courses should be natural, not sanitized, uniform, shorn of character” (Barton, 2008).

In effort to keep the MSL golf course as environmentally sustainable as possible it would be recommended to create an environmental plan or an environmental working group that will keep MSL golf course accountable and up-to-date with environmental efforts that can reduce the overall impact of the MSL golf course and will assist the MSL golf course in

making progressive steps toward environmental sustainability. A path forward can be to create environmental goals for the MSL golf course such as recycling goals and reductions in energy or waste. It is important to acknowledge the accomplishments of the environmental working group and share the environmental milestones with the golf members. This can also trigger a voluntary response from members and further contribute to the goals set by the committee.

The Pro Shop could offer a variety of environmentally friendly goods, such as biodegradable tees and golf balls as well as apparel derived from organic products.

Even though the MSL golf course uses reclaimed wastewater and conserves water by using inputs such as soil moisture, ET, wind factors, etc., the continual education will only promote water conservation and overall environmental sustainability of the MSL golf course. One course that is free and can be beneficial to MSL turf management staff is the Golf Irrigation Auditor course from the Irrigation Association (IA). Staff have an opportunity to become certified or just take the course as a means to increase knowledge and skills that can be used to maximize irrigation efficiency on the MSL golf course.

Another opportunity for improvement on the course is to implement a custom IPM plan for the MSL golf course. Since IPM strategies are already in place at MSL golf course, an IPM plan will basically ensure that knowledge of the MSL golf course is preserved for future staff. It will also improve the knowledge of current employees and can result in cost savings as time and labor are avoided as a result of having a developed IPM plan in place.

CONCLUSIONS

As a resident of NM, I understand the importance of stimulating the local economy as well as the importance and difficulty of sustainably managing environmental resources, especially on a golf course located in a semi-arid, high-desert region. Ironically, the economy will only prosper with proper management of the natural resources. NM lures tourists by marketing the natural assets of the state, including its aesthetic beauty, blue skies, mountainous landscape, and freshwater bodies such as rivers and lakes. Without proper management of these resources the current tourism industry could suffer

tremendously, i.e., golf industry. “Water resources are vital to NM, and many areas of the state are already facing potential shortages in meeting the needs of our growing cities, agriculture and manufacturing” (Agency Technical Work Group State of New Mexico, 2005). Adequate water resources are crucial to the survival of NM golf industry; any reduction in water resources available to the golf course industry could potentially be detrimental as the courses would not be able to provide favorable playing conditions to golfers and thus would reduce tourism and ultimately impact the growth of NM economy. Golf courses are of particular interest due to their immense water requirements, pesticide and fertilizer usage, and overall environmental impact. In high desert, semi-arid environments such as Santa Fe, NM, it is particularly challenging yet vital to manage golf courses in an environmentally sustainable way; fortunately, it can be done. The MSL golf course has proven to operate in an environmentally sustainable way.

Theoretically, as people become more aware of environmental issues they are also attracted to places that implement environmentally sound practices and further boost the economy.

The MSL golf course has also proven to develop land sustainably, which is often non-typical of golf courses. The MSL golf course and MRC sports facility was partially developed on an old landfill. Utilizing a degraded land source such as the old landfill drastically improved the quality of the area as well as created a recreational facility for avid sports players. Although there were minor disturbances such as fragmentation and displacement of native species during the construction of the golf course, the area is now inhabited with an abundance of wildlife and provides a refuge and sanctuary for migrating species. “Some golf courses have adopted strategies to protect the ecological balance of the golf course with programs to protect wildlife sponsored by partnerships between the US Professional Golf Association and the Audubon Society, among others” (Audubon International). The MSL golf course provides animals with an artificial habitat, it has been a successful nesting ground for blue herons, and it is a sanctuary for migrating birds and wildlife such as deer, elk and coyotes. The ponds are home to a plethora of insects and flora and fauna. This is not only beneficial to the ecology of the area, but it has provided a serene and natural playing environment for the golfers. The natural setting of the MRC is not only beneficial to NM economy as it provides jobs and attracts tourists to the area, but it

also provides a natural escape for the public as they can escape the urban sprawl and soak up nature's beauty. Green spaces such as the MRC and other golf courses can be beneficial to the mental and physical health to many visitors. Since the development of the MSL golf course the real estate value and desirability has increased dramatically and is considered to be "prime" real estate in Santa Fe, New Mexico. "Golf courses sequester a lot of carbon that reduces global warming; they provide oxygen and open space and wildlife habitat" (Barton, 2008).

The City of Santa Fe has an extensive Integrated Pest Management policy, which requires all properties that are either leased or operated by the City of Santa Fe to comply with the IPM policy. Thus the MSL golf course is obligated to adhere to the stringent IPM policy, which requires that the MSL golf course use alternative strategies when solving pest issues and requires a variance for any pesticide usage. Although the MSL golf course is authorized to comply with this stringent IPM policy, the MSL golf course managers have also realized the importance of protecting the health of their patrons' as well as the environment. Furthermore, the MSL golf course holds their patrons health and safety to the utmost standards. MSL golf course managers aim to provide patrons with the highest quality playing experience as well as provide a playing field that is safe and has little or no impact on the health of the community or the environment. The MSL golf course does not have a specific IPM plan for the course itself; however, their current strategies incorporate various pest management strategies that alleviate any need for synthetic pesticides and thus reduce the overall environment impact. The zero-pesticide tolerance on the MSL golf course has significant cost savings as chemical pesticides are costly and the application of them also has significant costs. Moreover, pests often become immune to pesticides and thus using less pesticides or using them more effectively reduces this "immunity" factor that could also increase long-term IPM costs.

In a survey conducted by Golf Digest and asked participants, "What would golf be like in a perfect world?" Participants answered as followed, "You'd be playing on an organic course. The maintenance equipment would be charged by solar power. Recycled water would be used for irrigation, and used efficiently and sparingly. There'd be a great variety of wildlife habitats" (Barton, 2008). Although the MSL golf course does not have solar

powered golf cars or maintenance equipment, nor is the course certified organic, the MSL golf course staff has taken great strides to manage the course as environmentally preferably as possible.

The MSL golf course has 90-acres of irrigated turf, yet consumes only 800,000 gallons of water per day. Yes, this may seem like a tremendous amount of water; however, the MSL golf course implemented a wastewater recovery plan during the developmental stages of the course that would avoid the use of fresh water resources for irrigation purposes. The MSL golf course utilizes only reclaimed wastewater for all irrigation purposes and uses as much as 3 acre feet of fresh water resources per year. Utilizing reclaimed wastewater results in the recovery of a highly precious resource as well as promoted the creation of jobs at the City of Santa Fe Wastewater Treatment Facility. As a user of reclaimed wastewater the MSL golf course is required to follow strict water testing regulations and hire professional experts to carry out testing and analysis; this stimulates job growth and overall financial growth in the surrounding area. The golf course itself provides a good membrane to recharge the groundwater aquifer as the majority of the landscape is permeable and there is little to no run-off. Due to the use of reclaimed wastewater the MSL golf course is prohibited from allowing standing water anywhere on the golf course. This reduces the chances of run-off, which is a typical environmental concern about golf courses as the run-off could contaminate local rivers and streams as well as groundwater resources.

“For example, a 1991 study prepared by the New York (NY) attorney general’s office found that some Long Island golf courses applied more than twenty-five tons of pesticides annually on courses – more than six times the amount that farmers used per acre. Birds and fish were often victims of these chemicals or of golf course construction that bulldozed trees, plants, or wetlands” (Kirsch).

The MSL golf course uses 100% reclaimed wastewater for all irrigation purposes and has undergone extensive training to ensure the current irrigation system is being managed optimally. Other advances in sustainably managing water resources include watering at optimal times and incorporating ET rates, wind factors, temperature, and precipitation into a daily irrigation plan. This further reduces the amount of water used at the MSL golf course for irrigation purposes. In an effort to further reduce water consumption the golf course is landscaped with natural vegetation, which uses drought-tolerant, native plants.

The MSL golf course is a composition of several types of cool-season grasses, which typically require more water than warm-season grasses. The MSL golf course selected turfgrass varieties that would withstand the harsh climate conditions of Santa Fe, NM, as well as provide an optimum playing condition. The turf managers employ tactics that not only conserve energy but also preserve the health of the turf. A reduction in the mowing frequency as well as an increase in rolling of the turfgrass contributes to the overall sustainability of the course. Reducing mowing frequency and increasing rolling of the turfgrass reduces the energy (fossil fuel) used for operating the mower and preserves the health of the turf, which also contributes to pest avoidance. Fertilizers are used sparingly and only when needed on the MSL golf course. Grass clippings are used as a natural nutrient supplement.

The MSL golf course could employ more energy conservation tactics such as the time of day the water is pumped from the City of Santa Fe Wastewater Treatment Facility. However, the golf course has integrated solar capabilities in the outdoor bathrooms, which significantly reduce energy usage and costs on the golf course. The MRC also has opted for energy-efficient golf cars despite the premium cost to lease in an effort to reduce energy consumption and ultimately reduce carbon dioxide emissions - not to mention an effort to abide by the City of Santa Fe IPM policy that indirectly reduces the amount of fossil fuels used, since most fertilizers and often pesticides are petroleum based products.

The MSL golf course implements sound waste management strategies that aim to divert waste from the landfill by recycling. However, these efforts could be amped up to capture the largest waste stream and recycle even more; this will take some time to create the recycling culture from the patrons as well as the staff.

The MRC is located near the New Mexico Department of Game & Fish. The NM Game and Fish is collaborating with the City of Santa Fe Marty Sanchez Links de Santa Fe Golf Course to develop an outdoor program for physically disabled youth. The City made a trade deal (which is required, as the City is prohibited from making donations) with the NM

Game & Fish. The City provides the NM Game and Fish a certain amount of water to fill up the pond, which will be used as an educational tool for the disabled youth. The water amount is minimal, which is estimated to be only “four gallons per minute.”

The MSL golf course provides an affordable and environmentally sustainable playing field. The course employs tactics that result in water conservation, pollution prevention, waste reduction and environmental protection, the quality of the experience due to the natural beauty of the area, as well as an excellent playing field, making Marty Sanchez Links de Santa Fe golf course an ideal golf course in a semi-arid high desert region.

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