TOWN OF LOS GATOS
PARKS AND SUSTAINABILITY
COMMISSION REPORT

MEETING DATE: 06/01/2026

ITEM NO: 2

DATE: June 1, 2026

TO: Parks and Sustainability Commission

FROM: Nicolle Burnham, Parks and Public Works Director

SUBJECT: Creekside Park Artificial Turf Replacement Alternatives

RECOMMENDATION: Receive a Report on Alternatives for Replacement of the Artificial Turf at Creekside Park and Consider a Recommendation to Town Council

BACKGROUND:

In Fiscal Year 2023-24 Town Council authorized $500,000 in a Capital Improvement Program Project as partial funding to replace the artificial turf at Creekside Sports Park. During budget development public comment was received regarding public health and environmental concerns associated with artificial turf.

On September 17, 2024 the Town Council authorized the Town Manager to execute an agreement with Kimley-Horn and Associates, Inc. to assess and evaluate the replacement of artificial turf versus the potential for constructing a new field of natural grass.

On July 27, 2025 Kimley-Horn submitted their report to staff (Attachment 1).

DISCUSSION:

Kimley Horn evaluated the advantages and dis-advantages of grass versus artificial turf with various potential infill materials. Their analysis suggests that conversion to natural grass will be more costly both in terms of construction and long-term maintenance. Natural grass will also significantly reduce the amount of time the field is available for play. Replacing the artificial turf is a lower cost choice in terms of construction and maintenance cost. These results are presented in Table 1, with the detailed analysis presented in Attachment 1.

PREPARED BY: Nicolle Burnham
Director

Table 1. Results of Analysis by Kimley-Horn for Replacement of Artificial Turf at Creekside Sports Park[3]

Alternative	Reconstruct with Natural Grass Field	Artificial - Crumb Rubber Infill	Artificial – Cork/Coconut Infill	Artificial – BrockFill Infill	Artificial Turf – PIVOT Material
Advantages / Disadvantages	Expensive construction and maintenance; requires intensive ongoing maintenance; limits field use	Industry standard; potential environmental implications of crumb rubber	Natural infill material; environmentally friendlier than crumb rubber	Engineered wood material infill; environmentally friendlier than crumb rubber	Artificial engineered grass with no infill required
Opinion of Construction Cost (2025$)[1]	$1,770,575	$1,174,071	$1,301,151	$1,343,511	$1,216,431
Projected 20-Year Lifecycle Cost[2]	$7,116,337	$2,535,407	$3,286,591	$2,896,879	$2,625,775
Annual Projected Cost per square foot of field	$101	$36	$47	$41	$37

Notes: 1. Cost includes 20% Contingency
2. Inclusive of Capital Costs
3. Refer to Table 4 of the Assessment Report for Details

In addition to the Kimley-Horn analysis, paid for by the Town, the State of California published in March 2026 a long-awaited study on the public health implications associated with artificial turf. The results can be found here: https://oehha.ca.gov/risk-assessment/report/release-final-report-synthetic-turf

Based on the results of Kimley-Horn's work and the State of California study, staff continues to recommend replacement of the artificial turf at this field. While crumb rubber infill is the cheapest solution in terms of capital and ongoing maintenance costs, staff recommends considering a more modern system for slightly higher cost – the PIVOT or the Brockfill material. Switching to one of these materials would reduce potential environmental impact associated with use of crumb rubber while providing long term durability and 24/7/365 playability.

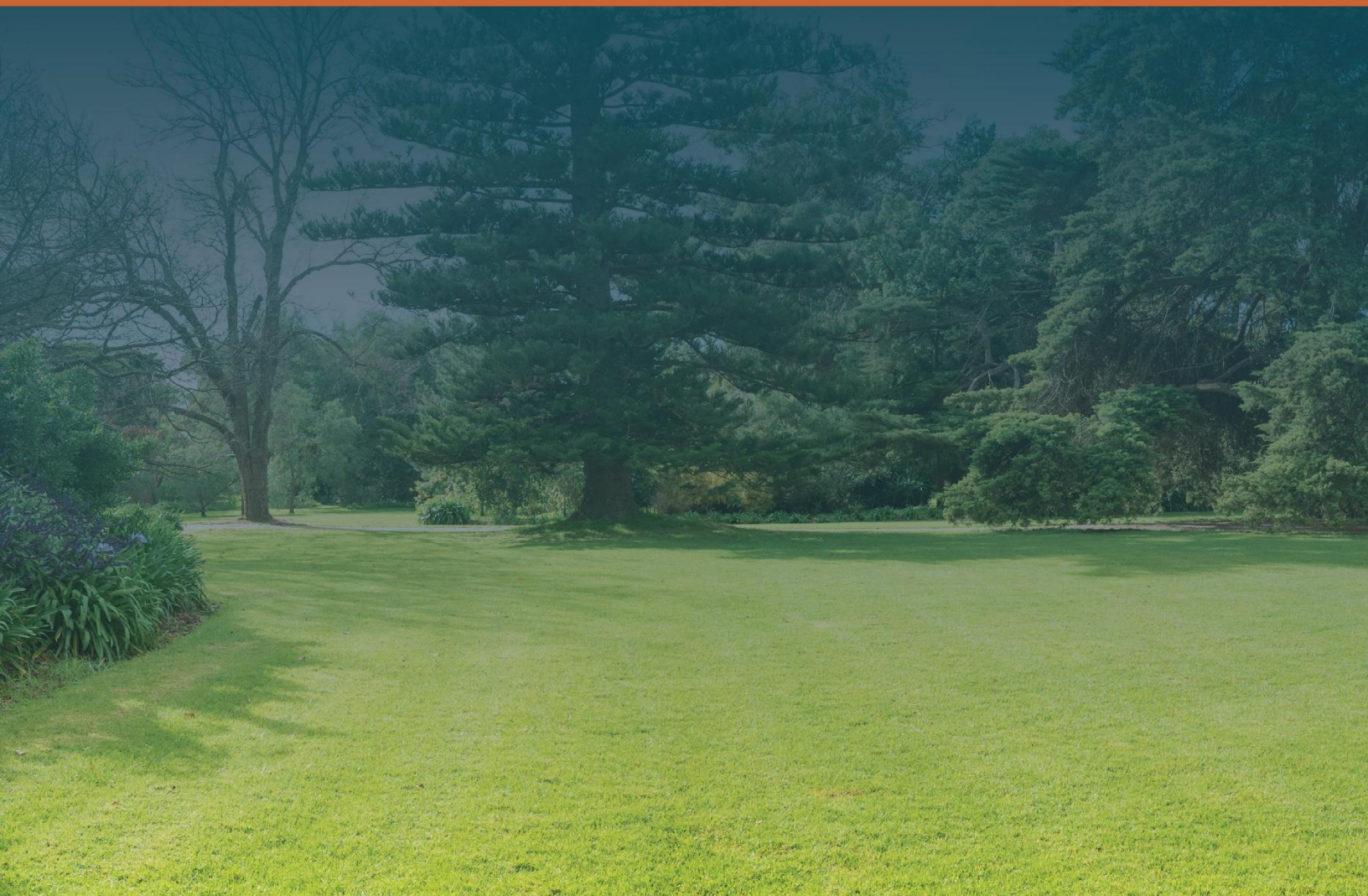
PREPARED FOR:

CREEKSIDE SPORTS PARK
ARTIFICIAL TURF REPLACEMENT ASSESSMENT

PREPARED BY:

Kimley»Horn

Expect More. Experience Better.



MEMORANDUM

To: Nicolle Burnham, Director
Parks and Public Works
41 Miles Avenue
Los Gatos, CA 95030

From: Matthew Morgan, PLA, ASLA, CLARB
Alex Jewell, AICP
10 S. Almaden Blvd, Suite 1250
San Jose, 95113

Date: 27 July 2025

Subject: *Artificial Turf Replacement Assessment at Creekside Sports Park*
Environmental, Planning, Operations & Maintenance Constraints & Benefits Assessment

INTRODUCTION

The Town of Los Gatos (Town) has used artificial turf from AstroTurf at Creekside Sports Park since 2013 located at 930 University Avenue. However, since this turf is at the end of its life and new concerns regarding the environmental and health impacts of artificial turf fields have been raised by community members, the Town seeks to evaluate the advantages and risks of using artificial versus natural turf. This assessment evaluates planning, environmental, operations and maintenance considerations associated with the construction and use of artificial turf fields versus natural grass fields. As part of this assessment, Kimley-Horn was asked to assess the operational and maintenance costs of the sports field for a 20-year (year) life cycle for artificial turf versus grass. The study considered staffing costs, maintenance costs including field striping, mowing, fertilization, annual repairs for natural grass, and routine and periodic maintenance costs for artificial turf.

The information in this document pertaining to environmental impacts will be based on a literature search on the subject conducted by Kimley-Horn staff for similar projects (such as a proposed artificial turf facility in Portola Valley). In our experience many of these issues are likely to be insignificant based on the results of available studies and continuous improvements to turf products. This information is compiled for planning-level consideration. Specific technical studies and/or California Environmental Quality Act (CEQA) review of the project will be scoped and budgeted separately upon request.

Research and analysis related to operational and maintenance issues included an evaluation of the existing field, a review of existing documents related to the field, and research of industry best practices for natural grass field and artificial turf field operations and maintenance. BerryDunn, Kimley-Horn's subconsultant completing this study, has over 30 years of experience operating and maintaining both natural grass and artificial turf fields, as well as over 10 years completing studies related to the operational and maintenance costs of the sports fields.

During the development of the Town's Capital Improvement Plan (CIP) and at the Town Council meeting on September 17, 2024, the Town heard comments related to the analysis of the existing turf itself and potential replacement of the existing turf. These comments included:

- Use and citation of the latest data based on modern products and maintenance/management practices
- Remediation, installation and ongoing lifecycle costs
- Material renewability, lifespan/lifecycle and recyclability
- Field-use capacity and lifespan
- Heat generation
- Pathogens, contaminants and allergens
- Toxicity of materials used in turf and crumb rubber fill materials
- Alternative products
- Water demand
- Water quality and drainage controls

Other issues and concerns raised by decision makers and the public on similar projects have included:

- Project visibility, appearance and color as seen from public viewpoints
- VOCs and off gassing
- Greenhouse gases
- General Plan policy consistency

The following is a summary of the data researched and analyzed regarding the above impacts of artificial turf versus natural turf, prepared for presentation to the Town of Los Gatos to review and use in determining a path forward for the field at Creekside Sports Park.

DETAILED ANALYSIS

Materials

Artificial turf has multiple layers consisting of a base layer made of gravel or stone, artificial grass carpet with backing material and artificial grass fibers, and infill materials that provide cushioning[1] Infill has historically been made from crumb rubber made from recycled tires or styrene butadiene rubber (SR). Tire crumb typically consists of metals, PAHs, VOCs, SVOCs, and other chemicals. Metals typically found in tire crumb rubber infill include zinc and some instances of lead and cadmium. PAHs are organic compounds that contain or may contain carcinogens. However, alternatives to recycled tires include other artificial materials, mineral-based materials, plant-based materials, or a mixture of natural and artificial materials.

Some of the more common alternative infill/no-infill products include the following:

- Cork/coconut – a natural infill material made from either natural cork, natural coconut fiber, or a combination of the two
- BrockFILL® – a natural infill material made from domestically sourced and treated pine wood, combined with natural sand
- PIVOT® Turf – a no-infill artificial turf product that eliminate the need for infill through a combination of different polyethylene yarns, of varying textures

Artificial grass-carpet and backing is typically made with Per- and Poly-fluoroalkyl Substances (PFAS)[2] and may also contain plastic fibers, such as polypropylene, polyethylene, and polyamide plastics, in the pile fiber and backing that may leak out microplastics. Direct health effects of PFAS in artificial turf is difficult to determine as there are limited studies and a wide variety of pathways of exposure.[3] Based on the artificial Turf Field Recycled Tire Crumb Rubber Research Under the Federal Research Action Plan published by the EPA in partnership with the Agency for Toxic Substances and Disease Registry (ATSDR), concentrations of metals in artificial turf users were similar to those in the general population and no difference in urine was observed between natural grass and artificial turf users[4]. A review of scientific literature published by the County of Santa Clara Public Health Department in 2024 concluded that it is uncertain whether artificial turf itself is harmful for people and the environment, though various components of artificial turf may be harmful considered on their own.

Natural grass could provide a safer alternative by eliminating chemicals found in the surfacing material or applied to the surface of artificial turf. However, natural grass is often maintained using synthetic pesticides and fertilizers, which may present their own health concerns. See **Table 1: Comparing Chemicals and Other Health Hazards or Artificial Turf with Natural Grass**.

[1] Toxics Use Reduction Institute (TURI) at UMASS Lowell, Athletic Playing Fields: Choosing Safer Options for Health and the Environment, Available at https://www.turi.org/publications/athletic-playing-fields-2/.
[2] TURI, Per- and Poly-fluoroalkyl Substances (PFAS) in Artificial Turf Carpet, Available at turi.org/publications/per-and-poly-fluoroalkyl-substances-pfas-in-artificial-turf-carpet/.
[3] US E.P.A., 2024, *Our Current Understanding of the Human Health and Environmental Risks of PFAS*, Available at https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas.
[4] U.S. EPA & CDC/ATSDR, 2024, *Synthetic Turf Field Recycled Tire Crumb Rubber Research Under the Federal Research Action Plan*, Available at https://www.epa.gov/system/files/documents/2024-04/tcrs-exposure-characterization-volume-1.pdf.

Table 1: Comparing Chemicals and Other Health Hazards of Artificial Turf with Natural Grass

Category	Subcategory	Artificial Turf	Natural Grass (conventional maintenance protocols)	Natural Grass (organic fertilizers and pesticides only)
Chemicals	Present in surface	Polymers, additives; respiratory hazards, e.g., zeolite	Ambient environmental exposures only	
	Applied to surface	Cleaners, disinfectants, herbicides	Synthetic pesticides, fertilizers	Soil health built through aeration, proper mowing practices, organic soil amendments, and other approaches
Other Health Hazards	Heat	Higher	Lower	
	Risk of skin abrasions and infections	Higher	Lower	
	Other injuries	Visible injury patterns		
Source: TURI, 2018, Athletic Playing Fields: Choosing Safer Options for Health and the Environment, Available at https://www.turi.org/publications/athletic-playing-fields-2/				

Volatile Organic Compounds (VOCs)

Volatile Organic Compounds (VOCs) are compounds that have a high vapor pressure and low water solubility[5]. Many VOCs are human-made chemicals that are used and produced in the manufacture of paints, pharmaceuticals, and refrigerants. Volatile organic compounds (VOCs) are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors. Synthetic infill material made from recycled tires has the potential to release VOCs. Tire crumb consists of over 350 chemicals found in tired crumb that have the potential to release VOCs, such as benzene, benzothiazole, hexane, naphthalene, styrene, toluene, xylenes.

A study conducted by the Office of Environmental Health Hazard Assessment (OEHHA) published in 2010 concluded VOCs on artificial turf fields were not detectible and emitted at levels too low to be measured in the open air[6]. However, recycled crumb rubber infill tested in laboratory settings emitted more VOCs as the

[5] EPA, 2024, What are volatile organic compounds (VOCs)?, Available at https://www.epa.gov/indoor-air-quality-iaq/what-are-volatile-organic-compounds-vocs.

[6] CalRecycle, 2010, Safety Study of Artificial Turf Containing Crumb Rubber Infill Made From Recycled Tires: Measurements of Chemicals and Particulates in the Air, Bacteria in the Turf, and Skin Abrasions Caused by Contact with the Surface, Available at https://plantscience.psu.edu/research/centers/ssrc/documents/2010-oehha-turf-study.pdf.

temperature increased[7]. This is consistent with the findings by the EPA stating that VOCs are consistently higher indoors.

Water Quality and Drainage
A 2021 Study comparing runoff and water retention between artificial lawns (short and long grass) and natural, living lawns found that artificial grass overall has greater volumes of runoff than living grass; and, between short artificial grass and long artificial grass, long artificial grass had greater runoff than short artificial grass.[8] Another study published by Utah State University found that artificial turf has a higher potential for runoff and lower potential for rainfall capture and infiltration[9]. Therefore, drainage systems, such as catch basins and exit drains, are required to prevent stormwater runoff.

There are environmental concerns pertaining to water quality due to contaminated runoff. Multiple studies measuring chemical leachate notes a high likelihood to be found in contaminated runoff deriving from artificial turf[10]. Infill particles and artificial grass blades have the potential to runoff into the environment while conventional natural grass has potential for fertilizer or pesticide contamination of water. An organic natural grass alternative would not result in water quality issues and water pollution.

Heat Generation
Surface temperatures on artificial/synthetic turf fields is greater than natural grass fields[11]. There has been research testing surface temperatures of alternative infill options compared to the typical black rubber associated with tire crumb infill; however, those alternatives only had the potential to lower surface temperatures by five or ten degrees but would offer little benefits when surface temperatures exceed 150° F[12]. Natural grass fields, in comparison with artificial turf fields, can reduce the heat island effect in urban areas. Heat generation is greater in artificial turf than natural turf, but in mild climates, such as that in the Town of Los Gatos, intense heat may be less frequent and unpredictable.

Greenhouse Gasses
The proposed artificial turf option would not replace existing natural grasses that are currently sequestering carbon[14]. Therefore, greenhouse gas emissions would be associated with construction. Sources of greenhouse gas emissions associated with artificial turf include the extraction of material resources, materials production, construction, use and maintenance, and disposal. Potential greenhouse gas conditions associated with operation of the artificial turf option are not expected to change with replacement of the turf field. There is potential to reduce GHG emissions associated with avoiding incineration in the disposal stage by reusing soil and rock materials onsite in addition to potential reuse of the turf mat and/or infill[15]. Reuse of materials would require less truck trips associated with transportation of soil and rock and

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[7] New York State, 2009, AN ASSESSMENT OF CHEMICAL LEACHING, RELEASES TO AIR AND TEMPERATURE AT CRUMB-RUBBER INFILLED SYNTHETIC TURF FIELDS, Available at http://www.synturf.org/images/NYDECcrumbrubfr2009.pdf.
[8] Simpson, T. & Francis, R., Artificial lawns exhibit increased runoff and decreased water retention compared to living lawns following controlled rainfall experiments, *Urban Forestry & Urban Greening*, Available at https://kclpure.kcl.ac.uk/ws/portalfiles/portal/154401824/Artificial_lawn_rainfall_UFUG_anonymised_revised_for_PURE.pdf
[9] Utah State University, 2023, Water Quality Impacts from Artificial Turf and Xeriscaping, Available at: https://extension.usu.edu/stormwater/residential/Water-Quality-Impacts-from-Artificial-Turf-Xeriscaping-Fact-Sheet.pdf
[10] Warner, 2022, Health Impacts of Artificial Turf: Toxicity Studies, Challenges, and Future Directions, Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC10262297/pdf/nihms-1903943.pdf
[11] New York State Department of Environmental Conservation, 2009, AN ASSESSMENT OF CHEMICAL LEACHING, RELEASES TO AIR AND TEMPERATURE AT CRUMB-RUBBER INFILLED SYNTHETIC TURF FIELDS, Available at http://www.synturf.org/images/NYDECcrumbrubfr2009.pdf
[12] Penn State Center for Sports Surface Research, 2012, Synthetic Turf Heat Evaluation – Progress Report, Available at https://plantscience.psu.edu/research/centers/ssrc/documents/heat-progress-report.pdf.
[14] University of Minnesota, 2014, The Potential of Turfgrass to Sequester Carbon and Offset Greenhouse Gas Emissions, Available at https://turf.umn.edu/news/potential-turfgrass-sequester-carbon-and-offset-greenhouse-gas-emissions.
[15] Magnusson, S. & Macsik, J., Analysis of energy use and emissions of greenhouse gases, metals and

have the potential to reduce greenhouse gas emissions. Overall, the greenhouse gas emissions associated with artificial turf is greater than natural turf; however, the differences in greenhouse gas emissions between artificial turf and natural turf may be greatly reduced with increased hours of use for artificial turf grass to decline in greenhouse gas [16]. Nonetheless, natural grasses sequester greenhouse gas emissions unlike artificial turf.

General Plan Policy Consistency

Replacement of the artificial turf would align with the Town of Los Gatos *Synthetic Turf Implementation Program* that would determine the appropriate use of artificial turf and consideration of alternative ground covers. The project would implement policies **PFS-1.1** and **PFS-1.2** as listed in the General Plan Chapter 6, Public Facilities, Services, and Infrastructure Element. The turf replacement would also align with the Review ***Open Space Standards Implementation Program*** by implementing policy **OSPR-4.4**. The turf replacement would also align with the ***Adopt Best Management Practices Implementation Program*** by implementing policy **OSPR-7.1**. See **Table 2: General Plan Policy Consistency Analysis** for project consistency with the General Plan. Overall, both options would be consistent with the Town of Los Gatos General Plan but the artificial turf option would align more closely with water conservation efforts.

organic substances from construction materials used for artificial turf, Resources, Conservation and Recycling 122 (2017) 362–372, Available at http://www.synturf.org/images/CFP-2017-03-Analysis_of_energy_use_and_emissions_of_greenhouse_gases,_metals_magnusson2017.pdf

[16] Zurich University of Applied Sciences, 2021, Life Cycle Assessment of Artificial and Natural Turf Sports Fields – Executive Summary, Available at https://digitalcollection.zhaw.ch/server/api/core/bitstreams/96187766-dbec-4f96-9281-7229483427c0/content.

Table 2: General Plan Policy Consistency Analysis

Policies	Turf Replacement Option Consistency	Natural Grass Option Consistency
Town of Los Gatos General Plan *Chapter 6, Public Facilities, Services, and Infrastructure Element*		
PFS-1 Ensure an adequate water supply for the Town's human, wildlife, and plant populations.		
PFS-1.1: Water Conservation Requirements. Require that landscaping and hardscaping for all development is designed to minimize water usage and enhance water conservation.	**The artificial turf option would be consistent with this goal because artificial turf requires less water than natural turf[17].**	**The natural grass option would be consistent with water conservation if recycled water is used. However, athletic fields require between one to two inches of water per week during the growing season[18].**
PFS-1.2: Bay-Friendly Landscaping. Require the use of the Bay-Friendly Landscaping Guidelines in addition to the landscaping standards in the GreenPoint Rated Building Guidelines for all new home construction and remodeled homes.	**The artificial turf option would not need to be consistent with Bay-Friendly Landscaping guidelines.**	**The natural grass option would be consistent with the Bay-Friendly Landscaping guidelines[19]. Sports fields are exempted from the maximum 25% total irrigated area listed in the Bay-Friendly Landscaping guidelines.**
Town of Los Gatos General Plan Chapter 7, Open Space, Parks, and Recreation Element		
OSPR-4 Consider the provision of recreation and open space in all development decisions		
OSPR-4.4: Design of Common Recreation Space Facilities. Consider health, welfare, and public safety in the design of common recreation space facilities.	**Although it is common to use artificial turf fields for playing, concerns over materials and toxicity would need to be reevaluated to ensure safe reinstallation of artificial turf. Suggestions for safe artificial turf to reduce injuries include FieldTurf's Revolution 360[20] surface utilized in the Home Depot Backyard Mercedes Benz Stadium.**	**Natural grass turf has been found to have less injuries when comparing NFL injury rates between typical artificial turf and natural grass surfaces[21].**
OSPR-7 Create and maintain open space areas and parks that complement and enhance natural habitats and neighborhoods.		
OSPR-7.1: Town Parks and Trails. Promote a system of Town parks and trails.	**The artificial turf option would be available more frequently, especially during the winter to promote usage of the sports field.**	**The natural turf option would still promote use of the sports field but would be limited during wet conditions.**

[17] Santa Clara Valley Water District, Artificial Turf Water Conservation Fact Sheet, Available at https://suwater.stanford.edu/sites/g/files/sbiybj19876/files/media/file/scvwd_artificialturf.pdf.
[18] Cornell University, 2025, Watering, Available at https://safesportsfields.cals.cornell.edu/routine-care/watering/.
[19] StopWaste & Alameda County, 2013, Bay-Friendly Landscaping Guidelines, Available at https://www.flowstobay.org/wp-content/uploads/2020/04/bay-friendly_landscape_guidelines_all_chapters.pdf.
[20] FieldTurf, 2025, Proven Safety, Available at https://fieldturf.com/en/why-fieldturf/proven-safety/.
[21] Venishetty N, Xiao AX, Ghanta R, Reddy R, Pandya NK, Feeley BT, Lower Extremity Injury Rates on Artificial Turf Versus Natural Grass Surfaces in the National Football League During the 2021 and 2022 Seasons. Orthop J Sports Med. 2024 Aug 29;12(8):23259671241265378. doi: 10.1177/23259671241265378. PMID: 39221040; PMCID: PMC11363235, Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC11363235/.

Project Visibility, Appearance, and Colors

Aerial views of an artificial turf field and natural grass field are distinguishable in that artificial turf fields are more consistent and uniform with their synthetic green color while natural grass fields may have varying shades and textures. Standard views for park visitors' viewing perspective would be similar in that viewers passing or viewing an artificial turf field would be able to note the consistent, uniform appearance while viewers passing or viewing a sports field may also be able to view inconsistent colors and textures. Field users would more easily identify inconsistency in appearance due to inconsistent textures, such as patchy areas and dirt areas, in natural grass fields. Field users would experience a more consistent playing experience with the consistent appearance of artificial turf fields.

The overall appearance differences between artificial turf and natural grass are highly dependent on proper maintenance of natural grass. Well-maintained natural grass would be more comparable to artificial turf but is often difficult to achieve. Further, artificial turf provides a more consistent appearance and is less variable and dependent on watering, weather conditions, and other maintenance requirements (e.g. mowing). Other variables that provide an inconsistent appearance for natural grass include bumps, mounds, or ridges associated with animals and insects.

The color differences between artificial turf and natural grass would vary depending on maintenance upkeep, particularly with natural grass. Natural grass requires consistent watering and can appear patchy due to heavy uses and weathering. An article published by the University of Minnesota Turfgrass Science Program on Turfgrass aesthetics noted that consistently green surfaces help reduce stress, increase energy, and improve overall mood for the viewer. Artificial turf grass would be more durable and maintain its color, resulting in little to no patchy areas. Artificial turf would have consistent green colors proven to be more aesthetically pleasing to viewers than natural grass with greater variability in color shades depending on watering, use (e.g. if one spot had greater activity than others, resulting in increased wear and tear), and weather conditions (e.g. if one area received more sun than others).

Overall, the visual appearance of well-maintained natural grass fields is comparable to artificial turf. However, well-maintained natural grass fields are harder to achieve to align with the higher visual quality of artificial turf.

Pathogens and Allergies

Allergen risks associated with artificial turf include potentially harboring more bacteria than natural turf, requiring proper maintenance and sanitation to remove bodily fluids and animal droppings and proper drainage to prevent the risk of mold. Mold is known to worsen allergy and asthma symptoms[22]. Nonetheless, there are mixed results in the literature on whether artificial turf harbors more bacteria than natural grass[23]. There have also been concerns on the potential for the presence of latex in recycled tire crumbs that may trigger latex allergy and asthma; however, the amount of latex in tire crumbs may be unknown and there have been little or no reports on latex allergy due to artificial turf fields[24].

Allergens commonly associated with natural grass include grass allergy with grass pollen allergy affecting approximately 40% of allergic patients[25]. Pathogens associated with turfgrass diseases include brown

[22] Allergy & Asthma Network, 2025, Mold Allergy, Available at: https://allergyasthmanetwork.org/allergies/mold-allergy/; Mayo Clinic, 2021, Mold Allergy, Available at https://www.mayoclinic.org/diseases-conditions/mold-allergy/symptoms-causes/syc-20351519.

[23] CHE Partnership, 2022, Environmental Health Impacts of Synthetic Turf and Safer Alternatives, Available at https://www.healthandenvironment.org/assets/images/webinarimages/Artificial%20Turf%20Q&A_FINAL.pdf.

[24] New York, 2009, Information About Crumb-Rubber Infilled Synthetic Turf Athletic Fields, Available at https://www.health.ny.gov/environmental/outdoors/synthetic_turf/crumb-rubber_infilled/docs/fact_sheet.pdf.

[25] Gangl K., Niederberger V., and Valenta R., 2013, Multiple grass mixes as opposed to single grasses for allergen immunotherapy in allergic rhinitis, Clin Exp Allergy, Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC6624134/pdf/EMS83545.pdf.

patch, dollar spot, pythium, helminthosporium leaf spot, fading out, gray leaf spot, fairy ring, take-all root rot, rust, slime mold, and nematodes[26].

When comparing artificial turf fields and natural fields, a study published by NIH found that both environments contained the presence of pathogens but had different microflora environments. That study also found that artificial turf fields harbor a microflora from anthropic and environmental sources whereas the natural grass carpets show a soil-related microbial community[27].

Field-use Capacity and Lifespan

A study conducted by the San Francisco Recreation & Parks Department estimates the average life span of artificial/synthetic fields is approximately 10 to 15 years. However, some manufacturers suggest that artificial grass can last up to 20 to 25 years with proper quality, installation, and maintenance[28]. The life span of a natural grass field varies depending on usage and maintenance but typically requires a major overhaul every ten years, maximum[29]. However, based on our experience, for optimal rehabilitation natural grass fields need to be rested each year during a growing season for a continuous and uninterrupted six to eight week period, then removed from service and replaced every five years.

Grady Mill, in the North Carolina State University publication AG-726-W 01/2010 BS, "Maximizing the Durability of Athletic Fields," provides a major tool in linking field-use capacity to play hours with standard inputs, he equates sustained good field conditions with 200 hours of play or fewer per year Good field conditions with some thinning of turf and localized wear areas are expected at 400 to 600 hours of use. Fair field conditions are expected at 800 to 1,000 hours of play. Over 1,000 hours of play result in with significant turf loss, field surface damage and increased potential for athlete injury.[31]

These guidelines assume implementation of all management inputs to support field health and playability. Few of those managing public sports field have the political support to limit play hours to match the level of maintenance inputs available to maintain field standards. The challenge remains trying to match play hour to field capacity. Based on the consultant's 40 years of experience in the industry, the actual hours of use of an artificial turf field range from 1.7 to 7.7 times the use of existing natural grass fields. To maintain the same annual level of play currently sustained on the artificial turf field at Creekside Sports Park, the Town could require as many as seven or more natural grass fields.

If a field has lights and field use of 200 hours or fewer per year, evenly spaced over the growing season, a routine maintenance program with two core aerification treatments per year is likely adequate to maintain an excellent quality playing surface. If the number of play hours increase and the maintenance inputs remain the same, the field quality will decrease to the level that existing maintenance supports. If additional appropriate maintenance inputs are applied to the field to counteract the field-use impact, the quality of the field will recover to the level supported by the management inputs. At a certain point increased play impacts cannot be overcome by increased management inputs.

A comparison of natural grass and artificial turf life cycle costs (20-year cycle) is helpful for understanding the options to convert existing fields or build new artificial fields.

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[26] University of Georgia, 2022, Turfgrass Diseases: Quick Reference Guide, Available at https://secure.caes.uga.edu/extension/publications/files/pdf/C%20891_7.PDF.
[27] Valeriani, 2019, Artificial-turf surfaces for sport and recreational activities: microbiota analysis and 16S sequencing signature of synthetic vs natural soccer fields, Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC6728760/pdf/main.pdf.
[28] Bella Turf, 2024, How Long Does Artificial Grass Actually Last?, Available at https://bellaturf.ca/blog/how-long-does-artificial-grass-actually-last/#:~:text=Conclusion,and%20under%20the%20optimal%20conditions.
[29] San Francisco Recreation & Parks, 2005, Natural and Synthetic Turf: A Comparative Analysis, Available at: http://www.cityfieldsfoundation.org/Comparison_fieldturf.pdf
[31] Grady L. Miller. January 1, 2010. "Maximizing the Durability of Athletic Fields." *North Carolina Cooperative Extension.* Accessed February 10, 2025 https://content.ces.ncsu.edu/maximizing-the-durability-of-athletic-fields

The 20-year life cycle cost analysis found that, despite the higher up-front and future replacement costs, an artificial turf field can provide a substantially lower net cost per hour of use than any of the Natural grass options because of the increased hours of potential use and additional revenue generated from those extra hours of use. The 1,000 hours of use assumed for an artificial turf field are well below the potential hours of use. For instance, many agencies operate on a similar schedule and achieve about 1,800 hours of use out of each of their artificial turf fields. Los Gatos has an estimated 2,120 hours of annual use of Creekside for soccer and lacrosse, far exceeding the average estimates used by most professionals. Additionally, since the field cannot be locked there is additional unaccounted for use, which puts further stress on the field. Another study analyzing the life-cycle cost of artificial turf fields and natural grass field also found that the installation and maintenance costs of artificial turf fields is greater than natural turf fields. However, the maintenance alone in artificial turf fields was less than that of natural grass fields. That study found that artificial fields would have greater number of uses than natural grasses and have the potential to be more cost effective than natural grass[32] as they are estimated to be open approximately 28% more of the time in year than natural grass fields due to their durability and ability to withstand heavy use[33].

Cost alone should not be the singular deciding factor, because comparing the two types of playing surfaces is more about comparing how they fit the needs and expectations of the department and community.

The one element in the comparison that must be understood is that natural grass systems do not accommodate the amount of usage hours annually that artificial turf systems do.

Installation and Lifecycle Costs
While completing studies on natural grass versus artificial turf over many years, we have contacted various manufactures/vendors, and facility operators who manage fields consisting of both types of surfaces.

There are a number of variables with natural grass, such as overuse, irrigation or not, type of grass, number of reseeds/overseeds per year, high use areas such as goal mouth rotations or not, maintenance hourly rates and overtime rates/policies, types of mowers, and unpredictable variables like the weather, disease, insect infestations, etc. Fields used exclusively for games tend to be more manicured, mowed lower and more often, irrigated, rested more often, and painted/chalked with lines. Schedules are managed based on current conditions, all of which are impacted by the previously listed factors. Fields used exclusively for practice tend to be mowed less frequently than game fields, mowed at a higher height than game fields, sometimes not irrigated, not rested as much (but should be rested as much or more) and lines not painted/chalked until they are no longer visible.

One of the attractions identified with artificial fields is that they do not have all of these variables, so they have more predictable maintenance costs, life spans, etc. The hours of use are constrained by predictable things like sports field lights, rather than unpredictable things like the weather, disease or insect infestations. Therefore, even if artificial turf costs more, the consistency, reliability, and other benefits might outweigh the additional cost.

Since Creekside Sports Park field is approximately 70,600 sq. ft. in area, the next two tables will be based on a field of that size. The following table compares the cost to maintain a 70,600 sq. ft. natural grass field to the cost to maintain a 70,600 sq. ft. artificial turf field over a 20-year period. The comparison of natural

[32] Daviscourt, B.L., Kowalewski, A.R., Lamrinos, J.G., and Eleveld, B., A Life-Cycle Cost Analysis of Synthetic Infill and Natural Grass Systems, Available at https://link.springer.com/epdf/10.1007/s43615-021-00115-z?sharing_token=uniwJ2WHiUkN9REj81Hw_ve4RwlQNchNByi7wbcMAY7L4Ern1XfrIjdlt_qN17FertDTtej1YLcdgpFN4S5ThTuXTDEM2belI6kutA-xSZ4W6vxXJ8jO6C1-9X5fHDknizCV6Z510j-zr6lFEaIdmKOc1wcejYer6vaYvJJo3MI%3D.
[33] Claudio L., Synthetic turf: health debate takes root, Environ Health Perspect. 2008 Mar;116(3):A116-22, doi: 10.1289/ehp.116-a116, Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC2265067/.

grass fields and artificial turf fields life cycle costs over 20 years compares the following data for both types of fields:

- Initial Major Renovation Construction Cost
- Refurbishing/Rest Costs
- Average Annual Maintenance
- Annual Maintenance
- Maintenance Costs for Refurbishment
- 20-Yr. Maintenance Costs
- 15-Yr. Maintenance Costs
- Maintenance Costs with Renovation
- 20-Yr. Total Maintenance and Capital
- Average Maintenance Cost/Yr. Over 20 Yrs.
- Average Annual Cost: Capital + Maintenance
- Average hours of usage per week
- Average weeks of usage per year
- Hours of use permitted per year
- Total Hours of Permitted Use in 20-Yr. Cycle
- Cost per Use

The required maintenance used was based on industry best practices. Annual maintenance costs for artificial turf fields are $19,648 less than natural grass areas (see **Table 3: Comparisons of Conceptual Installation Costs for Artificial Turf Fields and Natural Grass Field** and **Table 4: Comparison of Natural Grass Field and Artificial Turf Life Cycle Costs (20 Year Cycle) with 3% Annual Escalation** below for details).

Table 3: Comparisons of Conceptual Installation Costs for Artificial Turf Fields and Natural Grass Field

Natural Grass Field Replacement					7/26/2025
Item	Description	Estimated Quantity	Unit	Unit Price	Total
Creekside Sports Park Field					
Site Preparation					
1	Mobilization	1	LS	$100,000	$100,000
2	Stormwater And Non-Stormwater Pollution Control	1	LS	$10,000.00	$10,000
3	Clearing/Grubbing and Disposal of Artificial Turf	70,600	SF	$3.00	$211,800
4	Remove Artificial Turf Drain Rock Section (6" deep)	1,310	CY	$100.00	$131,000
5	Remove Compacted Subgrade (7" deep)	1,525	CY	$85.00	$129,625
6	Remove Existing Landscape/Vegetation (Bioswale)	625	SF	$10.00	$6,250
7	Construction Surveying and Staking	1	LS	$10,000.00	$10,000
8	Minor Grading/Grade Corrections	70,600	SF	$0.30	$21,180
				Subtotal	**$619,855**
Landscape and Irrigation					
9	Shrubs (Bioswale)	625	SF	$6.00	$3,750
10	No-float Compost Mulch (Bioswale)	625	SF	$0.50	$313
11	Soil Prep and Amendments (6" deep) to Remediate Lime-Treated Soil	70,600	SF	$0.50	$35,300
12	Install Drain Rock Layer for Sod (4" deep)	870	CY	$100.00	$87,000
13	Install Sand Base for Sod (9" deep)	1,960	CY	$45.00	$88,200
14	Furnish and Install Sod	70,600	SF	$3.00	$211,800
15	Irrigation System (Overhead Spray)	70,600	SF	$4.00	$282,400
16	120 Day Maintenance Period	1	LS	$24,000.00	$24,000
				Subtotal	**$732,763**
				Artificial Turf Field Replacement Subtotal	**$1,352,618**
				Design Contingency (10% of cost of improvements only)	$122,862
				Project Subtotal	**$1,475,479**
				Contingency @ 20%	$295,096
				Total	**$1,770,575**

Artificial Turf Field Replacement - Crumb Rubber Infill					7/26/2025
Item	Description	Estimated Quantity	Unit	Unit Price	Total
Creekside Sports Park Field					
Site Preparation					
1	Mobilization	1	LS	$100,000	$100,000
2	Stormwater And Non-Stormwater Pollution Control	1	LS	$10,000.00	$10,000
3	Clearing/Grubbing and Disposal of Artificial Turf	70,600	SF	$3.00	$211,800
4	Remove Existing Landscape/Vegetation (Bioswale)	625	SF	$10.00	$6,250
5	Construction Surveying and Staking	1	LS	$10,000.00	$10,000
6	Minor Grading/Grade Corrections	70,600	SF	$0.30	$21,180
				Subtotal	**$359,230**
Landscape and Irrigation					
7	Shrubs (Bioswale)	625	SF	$6.00	$3,750
8	No-float Compost Mulch (Bioswale)	625	SF	$0.50	$313
9	Artificial Turf (with infill)	70,600	SF	$8.50	$600,100
10	120 Day Maintenance Period	1	LS	$15,000.00	$15,000
				Subtotal	**$619,163**
				Artificial Turf Field Replacement Subtotal	**$978,393**
				Project Subtotal	**$978,393**
				Contingency @ 20%	$195,679
				Total	**$1,174,071**

Artificial Turf Field Replacement - Natural Cork/Coconut Infill					7/26/2025
Item	Description	Estimated Quantity	Unit	Unit Price	Total
Creekside Sports Park Field					
Site Preparation					
1	Mobilization	1	LS	$100,000	$100,000
2	Stormwater And Non-Stormwater Pollution Control	1	LS	$10,000.00	$10,000
3	Clearing/Grubbing and Disposal of Artificial Turf	70,600	SF	$3.00	$211,800
4	Remove Existing Landscape/Vegetation (Bioswale)	625	SF	$10.00	$6,250
5	Construction Surveying and Staking	1	LS	$10,000.00	$10,000
6	Minor Grading/Grade Corrections	70,600	SF	$0.30	$21,180
				Subtotal	**$359,230**
Landscape and Irrigation					
7	Shrubs (Bioswale)	625	SF	$6.00	$3,750
8	No-float Compost Mulch (Bioswale)	625	SF	$0.50	$313
9	Artificial Turf (with infill)	70,600	SF	$10.00	$706,000
10	120 Day Maintenance Period	1	LS	$15,000.00	$15,000
				Subtotal	**$725,063**
				Artificial Turf Field Replacement Subtotal	**$1,084,293**
				Project Subtotal	**$1,084,293**
				Contingency @ 20%	$216,859
				Total	**$1,301,151**

Artificial Turf Field Replacement - Natural BrockFill Infill					7/26/2025
Item	Description	Estimated Quantity	Unit	Unit Price	Total
Creekside Sports Park Field					
Site Preparation					
1	Mobilization	1	LS	$100,000	$100,000
2	Stormwater And Non-Stormwater Pollution Control	1	LS	$10,000.00	$10,000
3	Clearing/Grubbing and Disposal of Artificial Turf	70,600	SF	$3.00	$211,800
4	Remove Existing Landscape/Vegetation (Bioswale)	625	SF	$10.00	$6,250
5	Construction Surveying and Staking	1	LS	$10,000.00	$10,000
6	Minor Grading/Grade Corrections	70,600	SF	$0.30	$21,180
				Subtotal	**$359,230**
Landscape and Irrigation					
7	Shrubs (Bioswale)	625	SF	$6.00	$3,750
8	No-float Compost Mulch (Bioswale)	625	SF	$0.50	$313
9	Artificial Turf (with infill)	70,600	SF	$9.00	$635,400
10	Shock Pad	70,600	SF	$1.50	$105,900
11	120 Day Maintenance Period	1	LS	$15,000.00	$15,000
				Subtotal	**$760,363**
				Artificial Turf Field Replacement Subtotal	**$1,119,593**
				Project Subtotal	**$1,119,593**
				Contingency @ 20%	$223,919
				Total	**$1,343,511**

Artificial Turf Field Replacement - PIVOT (No Infill)					7/26/2025
Item	Description	Estimated Quantity	Unit	Unit Price	Total
Creekside Sports Park Field					
Site Preparation					
1	Mobilization	1	LS	$100,000	$100,000
2	Stormwater And Non-Stormwater Pollution Control	1	LS	$10,000.00	$10,000
3	Clearing/Grubbing and Disposal of Artificial Turf	70,600	SF	$3.00	$211,800
4	Remove Existing Landscape/Vegetation (Bioswale)	625	SF	$10.00	$6,250
5	Construction Surveying and Staking	1	LS	$10,000.00	$10,000
6	Minor Grading/Grade Corrections	70,600	SF	$0.30	$21,180
				Subtotal	**$359,230**
Landscape and Irrigation					
7	Shrubs (Bioswale)	625	SF	$6.00	$3,750
8	No-float Compost Mulch (Bioswale)	625	SF	$0.50	$313
9	Artificial Turf	70,600	SF	$7.50	$529,500
10	Shock Pad	70,600	SF	$1.50	$105,900
11	120 Day Maintenance Period	1	LS	$15,000.00	$15,000
				Subtotal	**$654,463**
				Artificial Turf Field Replacement Subtotal	**$1,013,693**
				Project Subtotal	**$1,013,693**
				Contingency @ 20%	$202,739
				Total	**$1,216,431**

Table 4: Comparison of Natural Grass Field and Artificial Turf Life Cycle Costs (20 Year Cycle) with 3% Annual Escalation

Natural Turf Field	
Initial Major Renovoation Construction Cost	***$1,770,575***
Refurbishing Cost - 5 times over 20 years *Field refurbishment at year 4, 8, 12, 16 & 20 after initial project*	**$4,428,000**
First Year Annual Maintenance Natural Grass *includes staff time and materials*	**$28,680**
20 Year Maintenance Costs	**$917,762**
20-Year Total Maintenance + Capital	**$7,116,337**
Average Maintenance Cost/Year over 20 Years	$45,888
Avg. Annual Cost: Capital +Maintenance	**$355,817**
Natural Turf Field Use	
32 weeks @ 2 hours per day on weekdays and 5 hours per day on weekends less 15% rain dates	
Hours per Week	20
Weeks of Use per Year	32
Hours Permitted per Year	640
Hours per Year minus 15% for Rain	544
Hours per Year * 20 years	10,880
*Refurbish/rest field every 4 years or 5 times in 20 yrs. Close fields for 20 of 32 playable weeks each time. (20 wks*20 hrs*5 rest periods)*	2000
Total Hours Permitted Use in 20-Year Cycle	8,880
Cost per Use *(Total Maint. + Capital)/(Total Permitted Hours in 20-Year Cycle)*	**$801**
Annual Cost per Sq. Ft.	**$101**

ANNUAL WATER BUDGET: 2,344,376 GPY ($70,331/year)*
*Based on current maintenance practices; assuming $.03/gal

Artificial Turf Field - Crumb Rubber Infill	
Initial Major Renovoation Construction Cost	***$1,174,071***
Refurbishing Cost *Carpet Replacement (year 12)*	**$836,536**
First Year Annual Maintenance Synthetic Turf *includes cost for staff to drag the field regularly and a contractor to come service (clean, minor seam repairs) the field annually*	**$16,400**
20-Year Maintenance Costs	**$524,800**
20-Year Total Maintenance + Capital	**$2,535,407**
Average Maintenance Cost/Year over 20 Years	*$26,240*
Avg. Annual Cost: Capital + Maintenance	**$126,770**
Synthetic Turf Field Use	
50 weeks @ 6 hours per day on weekdays and 10 hours per day on weekends	
Hours per Week	50
Weeks of Use per Year	50
Hours per Year	2500
Hours per Year * 20 years	50,000
*Refurbish field at 12 years. Close for 20 of 40 playable weeks. (20 wks * 50 hrs)*	1000
Total Hours Permitted Use in 20-Year Cycle	39,000
Cost per Use *(Total Maint. + Capital)/(Total Permitted Hours in 20-Year Cycle)*	**$65**
Annual Cost per Sq. Ft.	**$36**

ANNUAL WATER BUDGET: 126,092 GPY ($3,783/year)*
*Based on current maintenance practices; assuming $.03/gal

Artificial Turf Field - Natural Cork/Coconut Infill	
Initial Major Renovoation Construction Cost	***$1,301,151***
Refurbishing Cost *Carpet Replacement (year 12)*	**$1,460,640**
First Year Annual Maintenance Synthetic Turf *includes cost for staff to drag the field regularly and a contractor to come service (clean, minor seam repairs) the field annually*	**$16,400**
20-Year Maintenance Costs	**$524,800**
20-Year Total Maintenance + Capital	**$3,286,591**
Average Maintenance Cost/Year over 20 Years	*$26,240*
Avg. Annual Cost: Capital + Maintenance	**$164,330**
Synthetic Turf Field Use	
50 weeks @ 6 hours per day on weekdays and 10 hours per day on weekends	
Hours per Week	50
Weeks of Use per Year	50
Hours per Year	2500
Hours per Year * 20 years	50,000
*Refurbish field at 12 years. Close for 20 of 40 playable weeks. (20 wks * 50 hrs)*	1000
Total Hours Permitted Use in 20-Year Cycle	39,000
Cost per Use *(Total Maint. + Capital)/(Total Permitted Hours in 20-Year Cycle)*	**$84**
Annual Cost per Sq. Ft.	**$47**

ANNUAL WATER BUDGET: 126,092 GPY ($3,783/year)*
*Based on current maintenance practices; assuming $.03/gal

Artificial Turf Field - Natural BrockFill Infill	
Initial Major Renovoation Construction Cost	***$1,343,511***
Refurbishing Cost *Carpet Replacement (year 12)*	**$1,028,568**
First Year Annual Maintenance Synthetic Turf *includes cost for staff to drag the field regularly and a contractor to come service (clean, minor seam repairs) the field annually*	**$16,400**
20-Year Maintenance Costs	**$524,800**
20-Year Total Maintenance + Capital	**$2,896,879**
Average Maintenance Cost/Year over 20 Years	*$26,240*
Avg. Annual Cost: Capital + Maintenance	**$144,844**
Synthetic Turf Field Use	
50 weeks @ 6 hours per day on weekdays and 10 hours per day on weekends	
Hours per Week	50
Weeks of Use per Year	50
Hours per Year	2500
Hours per Year * 20 years	50,000
*Refurbish field at 12 years. Close for 20 of 40 playable weeks. (20 wks * 50 hrs)*	1000
Total Hours Permitted Use in 20-Year Cycle	39,000
Cost per Use *(Total Maint. + Capital)/(Total Permitted Hours in 20-Year Cycle)*	**$74**
Annual Cost per Sq. Ft.	**$41**

ANNUAL WATER BUDGET: 126,092 GPY ($3,783/year)*
*Based on current maintenance practices; assuming $.03/gal

Artificial Turf Field - PIVOT (No Infill)	
Initial Major Renovoation Construction Cost	***$1,216,431***
Refurbishing Cost *Carpet Replacement (year 12)*	**$884,544**
First Year Annual Maintenance Synthetic Turf *includes cost for staff to drag the field regularly and a contractor to come service (clean, minor seam repairs) the field annually*	**$16,400**
20-Year Maintenance Costs	**$524,800**
20-Year Total Maintenance + Capital	**$2,625,775**
Average Maintenance Cost/Year over 20 Years	*$26,240*
Avg. Annual Cost: Capital + Maintenance	**$131,289**
Synthetic Turf Field Use	
50 weeks @ 6 hours per day on weekdays and 10 hours per day on weekends	
Hours per Week	50
Weeks of Use per Year	50
Hours per Year	2500
Hours per Year * 20 years	50,000
*Refurbish field at 12 years. Close for 20 of 40 playable weeks. (20 wks * 50 hrs)*	1000
Total Hours Permitted Use in 20-Year Cycle	39,000
Cost per Use *(Total Maint. + Capital)/(Total Permitted Hours in 20-Year Cycle)*	**$67**
Annual Cost per Sq. Ft.	**$37**

ANNUAL WATER BUDGET: 126,092 GPY ($3,783/year)*
*Based on current maintenance practices; assuming $.03/gal

Note: *Annual maintenance practices for artificial turf through the Town's current contract with the artificial turf vendor include the Rhino Pro maintenance program: twice-yearly striping, inspection, cleaning, vacuuming, and minor seam repair.*

The following table details the qualitative comparison of a natural grass field and an artificial turf field.

Table 5: Qualitative Comparison of Natural Grass Field and Artificial Turf Field Life Cycle Costs (20-Year Cycle)

Comparison of Natural Grass Field and Artificial Turf Field Life Cycle Costs (20-Year Cycle)		
Qualitative Version	**Artificial Turf Field**	**Natural Grass Field –Scenario 1 4-Yr. Refurbishment Cycle**
Usage intensity: (allows over 1000 hrs/year, assume 1600)	**Quality: High**	**Quality: Poor**
	Expense: High	**Expense: High**
	Usage: High	**Usage: High**

Material Renewability

In terms of material renewability, there is possibility that artificial turf can be recycled through mechanical recycling or chemical recycling. Mechanical recycling has been difficult to implement with the diversity of materials included in artificial turf yarn and backing consisting of more than one polymer; however, Circular Polymers, a recycling center in Lincoln, Placer County, California, created a system that can separate and recycle polymers, polyethylene, and polypropylene from the polyurethane backing for FieldTurf. However, other manufactured products need to be determined for material composition to ensure proper recycling. Chemical recycling includes many challenges with requiring more energy than saved, lack in collection infrastructure, difficulty sorting, and consumer contamination[39].

[39] Rollinson, A., Oladejo, J, 2019, '*Patented blunderings', efficiency awareness, and self-sustainability claims in the pyrolysis energy from waste sector*. Resources, Conservation and Recycling, Volume 141, 233-242. https://doi.org/10.1016/j.resconrec.2018.10.038.

CLOSURE

Artificial turf fields have been found to be more cost-effective than natural turf fields. However, public health risks associated with artificial turf fields need to be further studied to make an informative decision on public health risks associated with artificial turf material. Available and reliable data on whether exposure to VOCs and PFAS on artificial turf players/users causes direct health concerns and damages is limited due to the recent focus on the matter. Water quality risks are associated with release of plastics into natural water with artificial turf while the risk of fertilizer and pesticide is associated with natural turf except for organic natural grasses. Heat generation is greater in artificial turf than natural turf but mild climates, such as that in the Town of Los Gatos, may not experience intense heat. It is recommended that even in mild climates, it may be beneficial for heat guidelines to be circulated and considered during hot days in which practices are encouraged to be conducted in the mornings or evenings[40].

Overall, the greenhouse gas emissions associated with artificial turf is greater than natural turf; however, the differences in greenhouse gas emissions between artificial turf and natural turf may be greatly reduced with increased hours of use for artificial turf grass to decline in greenhouse gas. Nonetheless, natural grasses sequester greenhouse gas emissions unlike artificial turf. Both options would be consistent with the Town of Los Gatos General Plan but the artificial turf option would align more closely with water conservation efforts. Safety risks associated with injuries may be reduced with improved artificial turf conditions, but overall injury risks may be lower with natural grasses. In terms of pathogens and allergies, both artificial turf and natural grass are at risk of pathogens while artificial turf may result in latex allergies and natural turf may result in grass allergies. Artificial fields would have greater number of uses than natural grasses and have the potential to be more cost effective than natural grass. Further research is needed to confirm the public health effects related to artificial turf.

Regarding installation, operations and maintenance costs, artificial turf fields can be more costly to install, less costly to maintain over the long term, and may create greater revenue by way of higher hours of annual usage. Natural grass field playing conditions are limited by the number of hours of usage. Good field conditions with some thinning of turf and localized wear areas are expected at 400 to 600 hours of use. Fair field conditions are expected at 800 to 1,000 hours of play. Over 1,000 hours of play results in significant turf loss, field surface damage, and increased potential for athlete injury. A natural grass field should be used a maximum of 8,800 to 10,880 over a 20-year period to maintain proper playing condition, while an artificial turf field can be used between 39,000 – 40,000 hours in the same period and maintain proper playing conditions. Artificial turf field playing conditions are not limited by the number of hours of usage. The actual hours of use of an artificial turf field range from 1.7 to 7.7 times the use of natural grass fields, based on the consultant's 40 years of experience in the industry. To maintain the same annual level of play currently sustained on the artificial turf field at Creekside Sports Park, the Town could require as many as seven or more natural grass fields. The average maintenance cost per year over the next 20 years, for a natural grass field is $45,888, in comparison to $26,240 for an artificial field. The 20-year total maintenance and capital cost for a natural grass field is $7,116,337 in comparison to $2,535,407 for an artificial field with crumb rubber infill, or a range of $2,625,775 to $3,286,591 for an artificial field with natural infill or a no-infill alternative.

However, perhaps the most applicable and potentially helpful cost data for the Town of Los Gatos, based on the Town's limited programmable sports field resources, is the dollar cost per use. With one field available in the Town for programmed recreation, virtually every available day of the year has been historically booked for use. Beyond that, the field is not secured by a perimeter fence, and often unscheduled use occurs outside of the hours of operation. The dollar cost per use calculation is based on the total capital cost of installation and maintenance, divided by the total number of permitted/playable

[40] National Recreation and Park Association, 2019, Synthetic Sports Fields and the Heat Island Effect, Available at https://www.nrpa.org/parks-recreation-magazine/2019/may/synthetic-sports-fields-and-the-heat-island-effect/.

hours. Over the course of the 20-year period that Kimley-Horn studied, natural grass fields have a cost of $801 per use, in comparison to an artificial turf field's cost of $65 - $84 per use. **Table 6: Summarized Comparison of Natural Grass Field and Artificial Turf Fields** outlines critical quantitative and qualitative considerations for both natural grass fields and artificial turf fields.

Table 6: Summarized Comparison of Natural Grass Field and Artificial Turf Fields

Consideration	Natural Grass Field	Artificial Turf Field
Estimated Installation Cost	$1,770,575	$1,174,071 - $1,343,511
Irrigation	Required	Not required
Drainage	May restrict playability	Does not restrict playability
Maintenance	More labor intensive	Less labor intensive
	Requires annual reseeding	Requires a minimum of once-per-year sterilization, or per manufacturer's recommendations
	Requires weekly mowing	Requires weekly sweeping
Field Markings	Temporary	Temporary or Permanent
	Requires weekly repainting of the lines	May require twice yearly repainting of lines
Playability	Limited	Unlimited
Special Events	Special events cause significant damage to natural grass fields	Special events do not typically cause significant damage to artificial turf fields
Weather	Precipitation can limit use	Extreme heat can limit use
Environment	Provides oxygen	Does not consume water, limited chemical applications
Life Expectancy	Requires regular periods of non-use	Does not require periods on non-use
	Requires renovation/replacement very two to three years. depending on types of usage	Replace top surface every 8 to 10 years. replace subsurface every 16 to 20 years.
Health Concerns	Use of herbicides and fertilizer	Concerns regarding materials used

REFERENCES

Adam, A., Barton, J., Cossey, R., Gainsford, P., Griffin, M., and Micklewright, D., Visual Color Perception in Green Exercise: Positive Effects on Mood and Perceived Exertion, Environmental Science & Technology 46: 8661–66, Available at https://botanyincontext.com/wp-content/uploads/2020/03/0267c-visualcolourperceptioningreenexercise.pdf.

Allergy & Asthma Network, 2025, Mold Allergy, Available at: https://allergyasthmanetwork.org/allergies/mold-allergy/; Mayo Clinic, 2021, Mold Allergy, Available at https://www.mayoclinic.org/diseases-conditions/mold-allergy/symptoms-causes/syc-20351519.

Barnes, M.R. & Watkins, E., Differences in likelihood of use between artificial and natural turfgrass lawns, Journal of Outdoor Recreation and Tourism, Volume 37, 2022, 100480, ISSN 2213-0780, https://doi.org/10.1016/j.jort.2021.100480, Available at https://www.sciencedirect.com/science/article/pii/S221307802100116X.

Bella Turf, 2024, How Long Does Artificial Grass Actually Last?, Available at https://bellaturf.ca/blog/how-long-does-artificial-grass-actually-last/#:~:text=Conclusion,and%20under%20the%20optimal%20conditions.

CalRecycle, 2010, Safety Study of Artificial Turf Containing Crumb Rubber Infill Made From Recycled Tires: Measurements of Chemicals and Particulates in the Air, Bacteria in the Turf, and Skin Abrasions Caused by Contact with the Surface, Available at https://plantscience.psu.edu/research/centers/ssrc/documents/2010-oehha-turf-study.pdf.

CHE Partnership, 2022, Environmental Health Impacts of Synthetic Turf and Safer Alternatives, Available at https://www.healthandenvironment.org/assets/images/webinarimages/Artificial%20Turf%20Q&A_FINAL.pdf.

Claudio L., Synthetic turf: health debate takes root, Environ Health Perspect. 2008 Mar;116(3):A116-22, doi: 10.1289/ehp.116-a116, Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC2265067/.

Cornell University, 2025, Watering, Available at https://safesportsfields.cals.cornell.edu/routine-care/watering/.

Daviscourt, B.L., Kowalewski, A.R., Lamrinos, J.G., and Eleveld, B., A Life-Cycle Cost Analysis of Synthetic Infill and Natural Grass Systems, Available at https://link.springer.com/epdf/10.1007/s43615-021-00115-z?sharing_token=uniwJ2WHiUkN9REj81Hw_ve4RwlQNchNByi7wbcMAY7L4Ern1XfrIjdlt_qN17FertDTtej1YLcdgpFN4S5ThTuXTDEM2belI6kutA-xSZ4W6vxXJ8jO6C1-9X5fHDknizCV6Z510j-zr6lFEaIdmKOc1wcejYer6vaYvJJo3MI%3D.

EPA, 2024, What are volatile organic compounds (VOCs)?, Available at https://www.epa.gov/indoor-air-quality-iaq/what-are-volatile-organic-compounds-vocs.

E.P.A., 2024, Our Current Understanding of the Human Health and Environmental Risks of PFAS, Available at https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas.

EPA & CDC/ATSDR, 2024, Synthetic Turf Field Recycled Tire Crumb Rubber Research Under the Federal Research Action Plan, Available at https://www.epa.gov/system/files/documents/2024-04/tcrs-exposure-characterization-volume-1.pdf.

Gangl K., Niederberger V., and Valenta R., 2013, Multiple grass mixes as opposed to single grasses for allergen immunotherapy in allergic rhinitis, Clin Exp Allergy, Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC6624134/pdf/EMS83545.pdf.

Kaufman, A.J. and V.I. Lohr, 2004, Does Plant Color Affect Emotional and Psychological Responses to Landscapes?, Acta Hort 639:229–33, Available at https://www.ctahr.hawaii.edu/kaufmana/downloads/Kaufman%20and%20Lohr%202004.pdf.

Magnusson, S. & Macsik, J., Analysis of energy use and emissions of greenhouse gases, metals and organic substances from construction materials used for artificial turf, Resources, Conservation and Recycling 122 (2017) 362–372, Available at http://www.synturf.org/images/CFP-2017-03-Analysis_of_energy_use_and_emissions_of_greenhouse_gases,_metals_magnusson2017.pdf

National Recreation and Park Association, 2019, Synthetic Sports Fields and the Heat Island Effect, Available at https://www.nrpa.org/parks-recreation-magazine/2019/may/synthetic-sports-fields-and-the-heat-island-effect/.

New York, 2009, Information About Crumb-Rubber Infilled Synthetic Turf Athletic Fields, Available at https://www.health.ny.gov/environmental/outdoors/synthetic_turf/crumb-rubber_infilled/docs/fact_sheet.pdf.

New York State Department of Environmental Conservation, 2009, AN ASSESSMENT OF CHEMICAL LEACHING, RELEASES TO AIR AND TEMPERATURE AT CRUMB-RUBBER INFILLED SYNTHETIC TURF FIELDS, Available at http://www.synturf.org/images/NYDECcrumbrubfr2009.pdf

Penn State Center for Sports Surface Research, 2012, Synthetic Turf Heat Evaluation – Progress Report, Available at https://plantscience.psu.edu/research/centers/ssrc/documents/heat-progress-report.pdf.

Rollinson, A., Oladejo, J, 2019, 'Patented blunderings', efficiency awareness, and self-sustainability claims in the pyrolysis energy from waste sector. Resources, Conservation and Recycling, Volume 141, 233-242. https://doi.org/10.1016/j.resconrec.2018.10.038.

San Francisco Recreation & Parks, 2005, Natural and Synthetic Turf: A Comparative Analysis, Available at: http://www.cityfieldsfoundation.org/Comparison_fieldturf.pdf

Santa Clara Valley Water District, Artificial Turf Water Conservation Fact Sheet, Available at https://suwater.stanford.edu/sites/g/files/sbiybj19876/files/media/file/scvwd_artificialturf.pdf.

Simpson, T. & Francis, R., Artificial lawns exhibit increased runoff and decreased water retention compared to living lawns following controlled rainfall experiments, Urban Forestry & Urban Greening, Available at https://kclpure.kcl.ac.uk/ws/portalfiles/portal/154401824/Artificial_lawn_rainfall_UFUG_anonymised_revised_for_PURE.pdf.

StopWaste & Alameda County, 2013, Bay-Friendly Landscaping Guidelines, Available at https://www.flowstobay.org/wp-content/uploads/2020/04/bay-friendly_landscape_guidelines_all_chapters.pdf.

Toxics Use Reduction Institute (TURI) at UMASS Lowell, 2018, Athletic Playing Fields: Choosing Safer Options for Health and the Environment, Available at https://www.turi.org/publications/athletic-playing-fields-2/.

TURI, 2020, Per- and Poly-fluoroalkyl Substances (PFAS) in Artificial Turf Carpet, Available at turi.org/publications/per-and-poly-fluoroalkyl-substances-pfas-in-artificial-turf-carpet/.

TURI, 2021, Testing Artificial Turf Materials: Options and Lessons Learned, Available at https://www.turi.org/wp-content/uploads/2024/09/Report.TestingArtificialTurfMaterials.April2021.pdf.

University of Georgia, 2022, Turfgrass Diseases: Quick Reference Guide, Available at https://secure.caes.uga.edu/extension/publications/files/pdf/C%20891_7.PDF.

University of Minnesota, 2014, The Potential of Turfgrass to Sequester Carbon and Offset Greenhouse Gas Emissions, Available at https://turf.umn.edu/news/potential-turfgrass-sequester-carbon-and-offset-greenhouse-gas-emissions.

University of Minnesota, 2019, Turfgrass aesthetics, Available at https://turf.umn.edu/news/turfgrass-aesthetics

Utah State University, 2023, Water Quality Impacts from Artificial Turf and Xeriscaping, Available at: https://extension.usu.edu/stormwater/residential/Water-Quality-Impacts-from-Artificial-Turf-Xeriscaping-Fact-Sheet.pdf

Valeriani, 2019, Artificial-turf surfaces for sport and recreational activities: microbiota analysis and 16S sequencing signature of synthetic vs natural soccer fields, Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC6728760/pdf/main.pdf.

Venishetty N, Xiao AX, Ghanta R, Reddy R, Pandya NK, Feeley BT, Lower Extremity Injury Rates on Artificial Turf Versus Natural Grass Surfaces in the National Football League During the 2021 and 2022 Seasons. Orthop J Sports Med. 2024 Aug 29;12(8):23259671241265378. doi: 10.1177/23259671241265378. PMID: 39221040; PMCID: PMC11363235, Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC11363235/.

Warner, 2022, Health Impacts of Artificial Turf: Toxicity Studies, Challenges, and Future Directions, Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC10262297/pdf/nihms-1903943.pdf

Zurich University of Applied Sciences, 2021, Life Cycle Assessment of Artificial and Natural Turf Sports Fields – Executive Summary, Available at https://digitalcollection.zhaw.ch/server/api/core/bitstreams/96187766-dbec-4f96-9281-7229483427c0/content.

APPENDIX

Appendix A

A Review of Benefits and Issues Associated with Natural Grass and Artificial Turf Rectangular Stadium Fields

A Review of Benefits and Issues Associated with Natural Grass and Artificial Turf Rectangular Stadium Fields

Prepared by a Staff Work Group from Montgomery County Public Schools, Montgomery County Department of Parks, Montgomery County Council, Montgomery County Department of Environmental Protection, and Montgomery County Department of Health and Human Services

September 14, 2011

FINAL REPORT

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Introduction:

On July 1, 2010, the Montgomery County Council's Transportation, Infrastructure, Energy, and Environment (T&E) Committee held a meeting with staff from Montgomery County Public Schools (MCPS), Maryland-National Capital Park and Planning Commission (M-NCPPC) Montgomery County Department of Parks (Parks), Montgomery County Department of Environmental Protection (DEP), and the Montgomery County Department of Health and Human Services (DHHS) to discuss health and safety issues associated with artificial turf fields in Montgomery County.

An outcome of the meeting was a T&E Committee request for the formation of a Staff Work Group to prepare a report that would provide guidance to the Committee in the face of concerns raised by some citizens and groups (see Appendices I and J) over the use of artificial turf fields in the County. The Staff Work Group would include staff members from MCPS, Parks, DEP, and DHHS, along with a representative from Council staff. Specifically, the Committee requested the Staff Work Group to further quantify the programming, environmental, cost-benefits, and other impacts of artificial turf vis-à-vis natural grass fields as part of its report. The T&E Committee requested this report by the end of 2010. However, it became evident that additional time was needed to complete research needed for this report.

The Draft Report of *A Review of Benefits and Issues Associated with Natural and Artificial Turf Rectangular Stadium Fields* was submitted for Public Comment on April 13, 2011. Public comments were received through June 7, 2011. A compilation of all public comments received during this comment period is included in Appendix N. Chapter IX, "Discussion of Public Comments to the Draft Report", provides a summary of the comments received, further discussion regarding some of the major points raised in the comments, and references to areas in the Final Report that reflect changes from the Draft Report.

The following Agency staff members were involved in the research and development of this report.

<u>MCPS</u>
Joe Lavorgna, Consultant to MCPS
James Song, Director of Facilities Management
Dr. William (Duke) Beattie, Director of Systemwide Athletics

<u>M-NCPPC (Parks)</u>
Mike Riley, Deputy Director, Montgomery County Department of Parks, M-NCPPC

<u>Montgomery County Staff</u>
Clark Beil, Montgomery County Department of Health and Human Services
Keith Levchenko, Montgomery County Council Staff
Steve Shofar, Montgomery County Department of Environmental Protection

Staff from the Maryland Soccer Foundation also provided substantial assistance to the group with regard to cost and maintenance assumptions for the natural grass and artificial turf fields they oversee at the

Maryland SoccerPlex in Germantown, Maryland. The SoccerPlex staff also provided information on best practice trends in the sports field management industry.

Executive Summary:

Montgomery County Public Rectangular Fields Inventory—Existing and Planned

Montgomery County currently has 160 existing full-sized public stand-alone natural grass rectangular fields plus seven existing artificial turf fields.[1] In addition, there are 317 public natural grass multi-purpose overlay fields. There are seven planned artificial turf fields in the FY2011-2016 Capital Improvements Program (CIP) period. The most imminent are Laytonia Recreational Park and Paint Branch High School, both planned for construction in 2011. Parks also plans to install artificial turf on the slab of the old Wheaton ice rink, a covered open-air facility, to allow soccer, lacrosse, futsal, and other uses. This project will generate income for the Parks Enterprise Fund.

Considerations for Use of Natural and Artificial Turf Fields

Need for Additional Fields: The Department of Parks prepares a park and recreation needs analysis every five years called the Land Preservation, Parks and Recreation Plan (formerly called the Park, Recreation, and Open Space (PROS) Plan). The Plan points to the need for 123 additional athletic fields in the County by the year 2020, of which 73 are full-sized rectangular fields.

Difficulty of Maintaining High Quality, High Use Natural Grass Fields: The necessary ingredients to sustain natural grass cover on an athletic field fall into three primary categories—construction, maintenance, and usage. All three must be carefully controlled, or the natural grass surface will likely become unsatisfactory and unsuitable for organized sports play. In order to sustain a high quality stand of natural grass on a field, it must be designed and constructed properly, be maintained regularly by qualified personnel, and have usage controlled and limited. If any one of the three factors is missing, natural grass cover on the field will deteriorate over time.

For Montgomery County Public Schools (MCPS), significant time, effort, and money is expended in trying to maintain safe, adequate playing conditions on high school stadium fields. This expenditure of resources consistently falls short of its goal, primarily because of the intensive wear and tear that result from so many sports and teams sharing natural grass high school stadium fields for competitive contests.

Finding: MCPS staff has identified the following operational benefits for artificial turf fields compared to existing natural grass high school stadium fields:

- Provides safer, more consistent, and more competitive surfaces for hundreds of MCPS and community teams.
- Provides safe, on-campus practice areas for MCPS athletic teams.

[1] Note: Artificial turf fields are also commonly called "synthetic turf" fields. Natural grass fields are also called "natural turf" fields. For clarity this report uses the terms, "artificial turf" and "natural grass" unless quoting other sources.

- A greater degree of MCPS compliance with Title IX. Field hockey contests are not played on the stadium fields at approximately half of the MCPS high schools because of unsuitable field conditions.
- Minimal cancellations for MCPS events. Prevailing weather conditions in the fall and spring force many cancellations, disrupting parents', as well as students', schedules. The only weather conditions that would cause a postponement on artificial turf fields would be lightening or abnormally severe weather.
- Significant savings in maintenance. Savings include not only seed, grass, fertilizer, and water, but also an enormous savings in time and effort by school staff and parent volunteers.
- Physical education classes having access to a safe, all-weather surface for activities during the school day for more than half of the school year.

Playability (Hours of Use)

A primary reason both Parks and MCPS support the construction of artificial turf fields at sites that meet certain criteria[2] is the increased hours of use possible with an artificial turf field compared to a high quality natural grass field. These increased hours of use are achieved without risking degradation of the field. In addition, even under limited hours of use, natural grass fields can suffer major damage from intensive play, especially when play occurs during or immediately after storm events. The increased hours of use provided by artificial turf fields also means that the County can avoid the costs and environmental impacts of building additional natural grass fields to meet ballfield needs. The increased playability also provides more flexibility for scheduling and co-locating events at a single location.

Finding: The actual hours of use of an artificial turf field (based on actual use of MCPS' artificial turf stadium fields and the artificial turf fields at the Maryland SoccerPlex) range from 1.7 to 7.7 times the use of existing natural grass fields (MCPS stadium fields, Parks fields, and Maryland SoccerPlex fields).

Lifecycle Cost Evaluation

A key factor in deciding whether to build an artificial turf field or a natural grass field is the comprehensive lifecycle costs (construction, maintenance, revenue, rehabilitation, replacement) including the cost per hour of use. The cost per hour of use is based on the estimated annual hours of use one can expect from the different field types based on the programming expected for the field.

The staff chose four natural grass field types to compare to a typical artificial turf field. The four natural grass field types consist of two different field bases (a ten-inch sand base and a native soil base) and two different grass types (Bermuda grass and Cool Season/Kentucky Bluegrass). The artificial turf field is assumed to be a polypropylene carpet with a crumb rubber infill.

Finding: The 20-year lifecycle cost analysis found that, despite the higher up-front and future replacement costs, an artificial turf field can provide a substantially lower net cost per hour of use at MCPS stadium fields than any of the natural grass options because of the many more hours of potential use and additional revenue generated from those extra hours of use. For fields that would

[2] For Parks, the primary criteria are: the ability of the site to handle intense use without conflicts with adjacent communities, adequate parking, and the existence or future capability of lighting. MCPS supports installing artificial turf at high school stadium fields as part of comprehensive high school modernization projects.

be dedicated for Parks' use (i.e., no MCPS use), the cool season native soil field has the lowest net cost and cost per hour of each of the fields considered (including a Parks artificial turf field). However, this result is highly dependent on hours of use and revenue assumptions. While the natural grass hours of use are assumed to be a maximum, the 1000 hours of use assumed for a Parks artificial turf field are well below the potential hours of use. For instance, the Maryland SoccerPlex operates on a similar schedule to Parks and achieves about 1,800 hours of use out of each of its artificial turf fields.

Public/Human Health Concerns

Due to the distinct physical characteristics of artificial turf systems, concern has been raised over potential adverse health effects related to use of these systems. The potential physical health effects associated with artificial turf systems (carpet and infill) include:

- chemical exposures
- heat-related illnesses
- abrasions/turf burns
- injuries, infections, and allergic reactions

In the absence of either an environmental impact assessment or a health impact assessment on the installation and use of artificial turf fields, the Staff Work Group identified some of the areas of potential human risks that were raised during the compilation of information that forms this report. This is not a complete set of risks. A formal process would be required to identify and examine all the human health risks from all the artificial turf field materials under consideration. Such an analysis was beyond the scope and capacity of the Artificial Turf Staff Work Group.

Finding: Parks and MCPS believe that reliance should be placed on the various government studies referenced in this report that have looked at the human health issues associated with artificial turf fields (and crumb rubber infill in particular) and have not found levels of concern that warrant avoidance of the construction of new artificial turf fields with crumb rubber infill.

Artificial Turf Heat Issue

One characteristic of artificial turf fields that has been well documented is the higher field temperatures on artificial turf fields, compared to temperatures on natural grass fields under similar weather conditions. These conditions may vary, depending on the color and other specifications of the artificial turf carpet and the type of the infill material used.

Staff Work Group Recommendations:

- It is evident that surface and ambient temperatures on artificial turf fields can get quite hot. The Staff Work Group believes MCPS should include the artificial turf heat issue in its athletic handbook in order to address circumstances where these fields are being used and/or supervised by MCPS directly during peak heat conditions (for summer and early fall team practices and physical education classes, for instance). This guidance should provide for an assessment of field conditions on a case-by-case basis by the athletic staff at the school (considering ambient and field temperature readings).
- The Staff Work Group believes common permit language and advisory signage for all artificial turf fields managed by MCPS, Parks, and Community Use of Public Facilities (CUPF) should be utilized.
- CUPF should develop specific heat guidelines to govern the leasing of artificial turf fields to outside groups.

Environmental Impacts

The Staff Work Group asked the Montgomery County DEP to provide its perspective on artificial turf, based on its review of the various studies (see Appendix F). DEP staff were asked whether MCPS and Parks should not build any more artificial turf fields pending further environmental study. To date, DEP has not taken a position on this question. DEP has also not provided specific recommendations regarding the construction and use of artificial turf, such as whether water quality should be monitored for existing fields, if specific stormwater management practices should be utilized, or whether particular alternative infill choices should be pursued.

However, DEP is working with Parks on a monitoring plan for the new Laytonia Park, which is planned to include two rectangular natural grass fields and one artificial turf field. The location is in the Rock Creek Special Protection Area (SPA) and therefore, as the property owner, Parks is required to conduct water quality monitoring on proposed Best Management Practices (BMPs) to assure that they are protecting water quality. M-NCPPC is working together with DEP and the Department of Permitting Services (DPS) to develop a monitoring plan that will evaluate the effects of the Laytonia artificial turf field on water quality. The details of that plan are still being developed and are not available for this report. The results of this monitoring effort can help determine whether further monitoring of other artificial turf sites may be warranted.

Since the Staff Work Group did not receive specific recommendations from DEP, the group reviewed a number of studies that focused on environmental issues and which included recommendations by other Environmental Departments.

Connecticut Department of Environmental Protection, July 2010

The full report is available at:
http://www.ct.gov/dep/cwp/view.asp?a=2690&Q=463624&depNav_GID=1511, along with reports from other Connecticut agencies looking at various issues of concern regarding artificial turf.

San Francisco Department of the Environment (SFE) (as part of a Synthetic Playfields Task Force Report completed in August 2008)

The full Task Force Report is available at: http://www.superfill.net/dl010808/SFParks_Playfields_8.21.08.pdf. The Task Force took a broad look at artificial turf issues and, more relevantly for this section, included SFE findings and recommendations.

Finding: While both the Connecticut and San Francisco environmental departments identified potential environmental impacts, neither study determined that these impacts were of sufficient concern to warrant a moratorium on the construction of artificial turf fields with crumb rubber infill. Instead, both departments recommend specific practices to reduce or mitigate these impacts.

Recommendation: Parks and MCPS staff should include language in future contracts requiring the recycling of artificial turf fields by the new field installer.

Recommendation: Parks and MCPS staff should explore incorporating some of the environmental testing requirements identified in the City of San Francisco artificial turf specification into future specifications for artificial turf fields constructed for Parks and MCPS.

Recommendation: Parks and DEP staff should collaborate on the development of a water quality testing regime at the future Laytonia Park.

Alternative Infill Products

The artificial turf industry is expanding rapidly. Turf companies and infill manufacturers are attempting to respond to concerns with Styrene-Butadiene-Rubber (SBR) infill materials and are developing new alternatives. Because the industry is rapidly changing, decisions made on new companies and products should be well researched to make sure that the money spent on artificial turf systems is based on sound lifecycle cost information.

Finding: Many owners, installers, and suppliers of artificial turf fields believe that crumb rubber is the best infill product on the market because it has been field tested and proven for performance, is readily available, utilizes recycled material, and is cost-effective over a number of years. Alternative infill materials are being marketed primarily to compete with crumb rubber, based on the negative perceptions attributed to SBR. While some of the alternative infills may show promise in terms of durability and performance over time, Parks and MCPS staff believe it is too early to invest in an unproven product until a greater track record is established for many of these materials.

Recommendation: Parks and MCPS believe that County agencies should continue to monitor the success or failure of alternative infills before considering a change from SBR infill material.

NOTE: Parks will consider installing and evaluating an alternative infill product if it installs artificial turf at the old Wheaton Ice Rink, due to the relatively small size of the surface as compared to an outdoor field. Parks will only specify an alternative infill if it can determine that the alternative has high potential to deliver equivalent performance to SBR at a reasonable cost without raising equivalent health and environmental concerns.

I. Background

Montgomery County Public Rectangular Fields Inventory—Existing and Planned

As shown in Chart I-1 below, there are currently 160 existing full-sized stand-alone natural grass rectangular fields, plus seven existing artificial turf fields. In addition, there are 317 natural grass multi-purpose overlay fields. There are seven planned artificial turf fields in the FY2011-2016 Capital Improvements Program (CIP) period. The most imminent are Laytonia Recreational Park and Paint Branch HS, both planned for construction in 2011.

For Montgomery County Parks, site selection criteria for public artificial turf fields have included adequate site area for full-sized fields, parking, field lighting or the capability for lighting, and space to buffer communities from intense usage. These criteria generally limit the sites to regional/recreational parks and community recreation centers. There are presently no plans for artificial turf in local/community use parks or on multi-purpose overlay fields. For MCPS, planned fields include only high school stadium fields. However, MCPS staff have received inquiries from some non-high school PTAs and community groups about installing artificial turf fields at other school sites. No formal requests have been received at the time of this report.

Chart I-1. Tabulation of Existing and Proposed Natural and Synthetic Turf Rectangular Fields on M-NCPPC, MCPS, and County Properties (not including private sites and municipalities)

Public Facilities	Full-Size Stand Alone Rectangular Fields						Existing Natural Turf Rectangular Overlays[1]
	Natural Turf		Artificial Turf		Total		
	Existing[2]	Planned[3]	Existing[4]	Planned[5]	Existing	Planned	
M-NCPPC Parks							
Regional / Recreational	16	6	2	1	18	7	2
Local / Community-Use	92	3	0	0	92	3	55
MC Public Schools							
High School Stadium	22	*(3)*	2	*3*	24	0	0
High School Practice	12	0	0	0	12	0	56
Elementary & Middle Schools	1	0	0	0	1	0	199
MC Recreation Department	0	2	0	1	0	3	5
Maryland SoccerPlex	17	2	3	2	20	4	0
Totals	160	10	7	7	167	17	317

[1] Overlays are multi-purpose natural turf areas where baseball / softball diamonds typically overlap rectangular fields. They generally do not support full sized rectangular fields. There are 317 rectangular overlays at park and school sites.

[2] There are 160 existing full-size stand-alone natural turf soccer fields at Park, School, and County sites. At MCPS, the full-size stand-alone fields are at high schools, with one at Tilden Middle School which is a former high school. All other MCPS elementary and middle school fields at schools are considered shared use multipurpose overlays, which are generally permitted by CUPF.

[3] Thirteen new full-size stand-alone natural turf soccer fields are planned over the six-year CIP cycle. They are: Laytonia Recreational Park (2), Northwest Branch Recreational Park (4), East Norbeck LP (1), Greenbriar LP (1), North Four Corners LP (1), Mid-County Community Recreation Center (1), White Oak Community Recreation Center (1), and Maryland SoccerPlex (2). Three existing MCPS stadium fields will be converted to artificial turf fields.

[4] The seven existing synthetic turf fields are at Blair Recreational Park / HS (1), Fairland Recreational Park (1), Richard Montgomery HS (1), Walter Johnson HS (1), and Maryland SoccerPlex (3).

[5] There are seven synthetic turf fields presently planned over the six-year CIP, including new synthetic turf fields at the future Laytonia Recreational Park (1) and North Potomac Community Recreation Center (1), and conversions of existing natural turf soccer fields to synthetic turf at Paint Branch HS (1), Gaithersburg HS (1), Wheaton HS (1), and Maryland SoccerPlex (2).

Montgomery County Parks Fields

Natural Grass Fields

There are currently 108 full-sized stand-alone rectangular fields in Montgomery County Parks. Sixteen of these fields are in regional or recreational parks which are secured and restricted for use by permit only. The remaining 92 fields are in community-use parks and are available for walk-on use when not permitted.

An additional nine natural grass fields are planned in Parks over the current six-year CIP cycle. Six will be in regional/recreational parks and three will be in community use parks. One additional artificial turf field is planned for the Laytonia Recreational Park, and two new artificial turf fields are under consideration by the Maryland Soccer Foundation for the Maryland SoccerPlex.

Artificial Turf Fields

There are two existing artificial turf fields built and controlled by the Parks Department. Parks' first artificial turf field was built in 2008 at Montgomery Blair High School. When the property known as the

"Kay Tract" was purchased for Blair High School, a portion of the funding came from State Program Open Space funds. Through a Memorandum of Understanding (MOU) with the County and MCPS, Parks manages and maintains three athletic fields in what is known as the "recreation parcel" at Blair, including the stadium field used by MCPS for football games and other school sports. This unique arrangement was created in part to allow for maximum community use of the three fields outside of school needs and also to justify the use of Program Open Space funding. The stadium field was originally constructed as a natural grass field in 1998 in conjunction with the construction of the new high school. From the start, there was wide-spread dissatisfaction with the quality of turf on the field, with overuse being the primary cause of the problem. Parks originally permitted the stadium field for community use to an array of groups, including the Washington Chiefs Football League, but eventually ceased permitting the field because school use alone left the field in undesirable condition most of the time.

When Parks began considering artificial turf as one of several options to bridge the gap between supply and demand for field time, it conducted a detailed site selection process to prioritize venues for artificial turf fields. The primary criteria for sites were the ability to handle intense use without conflicts with adjacent communities, adequate parking, and the existence or future capability of lighting. The stadium field at Blair emerged as the top site, and a rectangular field at Fairland Recreational Park was the second priority.

Fairland Recreational Park was opened in 1995. It included five athletic fields, including a full-sized rectangular field. Similar to Blair, the demand for use was high and the natural grass surface rapidly deteriorated. The field was renovated several times, but the turf cover did not stand up to the use. It was recently converted to artificial turf and opened for community use by permit in December 2010.

There are currently three planned artificial turf fields for Parks facilities over the next six years; one at Laytonia Recreational Park and two at the Maryland SoccerPlex. Parks also plans to install artificial turf on the slab of the old Wheaton ice rink, a covered open-air facility, to allow soccer, lacrosse, futsal, and other uses. This project will generate income for the Parks Enterprise Fund.

Laytonia Park is currently approved in the CIP to provide four baseball/softball diamonds. However, current needs, as defined by the most recent Land Preservation, Parks and Recreation Plan, call for a greater need for rectangular fields. In response, in FY11, the Planning Board approved a change to the Laytonia plan to include three rectangular fields and one diamond field. The new plan calls for one of the rectangles to be artificial turf and the other two to be natural grass. Parks believes that the construction of premier natural grass and artificial turf rectangular fields side-by-side in the same recreational park provides an excellent opportunity to fully test and evaluate the comparative costs and benefits of both grass and artificial turf athletic field surfaces in Montgomery County. Parks will implement a program, in cooperation with other agencies, to carefully evaluate both grass and synthetic surfaces on rectangular athletic fields. The results of this program will be used to determine specifications for future athletic field construction and renovation projects in the parks, and the results could be used by the Planning Board and County Council in the review of other public and private projects that include athletic fields.

MCPS High School Stadium Fields

Below are specific facts concerning MCPS athletic fields:

- Total Schools - MCPS has 25 high schools.
- Stadium Fields - MCPS has 25 stadium fields that are used primarily for games and contests. (The stadium field at Montgomery Blair High School is owned and maintained by Montgomery County Parks.)
- Types of Stadium Fields – Twelve stadium fields have bluegrass or fescue on native soil. Ten stadium fields have Bermuda grass on native soil. Three stadium fields (Montgomery Blair, Richard Montgomery, and Walter Johnson) have artificial turf.
- Stadium Field Use – At 15 high schools, twelve teams share the stadium field for home games. These teams include: varsity and junior varsity teams in field hockey, football, boys' lacrosse, girls' lacrosse, boys' soccer, and girls' soccer. At ten high schools, the field hockey team plays on a separate field because of adverse stadium field conditions.
- Maintenance of Stadium Fields – Each school receives a set amount each year for its athletic program, a portion of which is allocated by each school for stadium field maintenance. In addition, stadium field maintenance is supplemented by booster club donations and volunteer efforts.
- On-Campus Full Practice Fields - In addition to the 25 high school stadium fields, there are 56 approximately full-sized rectangular practice areas contained on MCPS high school sites. Many of these practice fields overlap baseball and/or softball outfields – they can be used as a rectangular field in the fall, but not in the spring during the baseball/softball season.
- On-Campus "Partial" Fields - There are twelve partial rectangular fields at MCPS high school sites – fields that are not regulation-sized but can accommodate drills and small team practices.
- MCPS Fields Permitted by Community Use of Public Facilities (CUPF) – When not scheduled for school activities, the three artificial turf stadium fields are permitted for community use through CUPF. The 56 full-sized practice fields mentioned above, in addition to the 22 natural grass stadium fields and the 12 partial fields, are not permitted for public use.
- Practice Fields Adjacent to the School - There are nine approximately full-sized rectangular fields located on property adjacent to high school sites (but off the school property).
- Off-Campus Fields – 124 MCPS teams that use rectangular fields practiced off-site last year. These 124 teams utilized approximately 45 fields.

Artificial Turf Fields Information

In the United States, there are approximately 5,500 artificial turf fields currently installed, according to the Synthetic Turf Council (www.syntheticturfcouncil.org).

Artificial turf fields consist of an underground drainage system with a compacted gravel base, a polypropylene or nylon fiber carpet, and infill product(s) used to hold the carpet fibers upright and to cushion the surface to mimic the characteristics of natural grass. Different manufacturers vary the carpet fibers and infill materials to distinguish their product.

In Maryland and the Washington metropolitan area, there are 54 artificial turf fields installed at 234 public high schools (as of June 2010, see Appendix A). In Montgomery County, outdoor artificial turf fields have been built at 16 locations, with one in design review by the Montgomery County Department of Permitting Services (DPS), as shown in chart I-2. Of the 16 field locations in Montgomery County, there are seven artificial turf fields at schools or parks (including three at the Maryland SoccerPlex in Germantown). There also are several indoor artificial turf fields in the County.

Chart I-2

Outdoor Artificial Turf Fields* In Montgomery County

	Location	Status	Date Opened	Description
1	Bullis School	Constructed	2004	rectangular field
2	Church of the Little Flower	Constructed	2004	playground field
3	Connelly School of the Holy Child	Constructed	2010	rectangular field
4	Fairland Regional Park	Constructed	2010	rectangular field
5	Georgetown Prepratory School	Constructed	2006	rectangular field
6	Good Counsel High School	Constructed	2009	rectangular field
7	Holton Arms School	Constructed	2007	rectangular field
8	Holy Redeemer Church	Constructed	2010	playground field
9	Landon School	Constructed	2007	rectangular field
10	Maryland SoccerPlex	Constructed	2007	3 rectangular fields
11	Mater Dei School	Constructed	2009	rectangular field
12	Montgomery Blair High School	Constructed	2008	rectangular field
13	Our Lady of Lourdes	Constructed	2008	rectangular field
14	Richard Montgomery High School	Constructed	2009	rectangular field
15	St Andrew Episcopal School	Constructed	2008	2 rectangular fields & baseball diamonds
16	Walter Johnson High School	Constructed	2010	rectangular field
17	The German School	In Permitting Process		
	Indoor Fields in Montgomery County			
1	Champions Field House	Constructed	2008-2011	5 rectangular fields of varying sizes (1 section rolls up)
2	Maryland Soccerplex	Constructed	2000	2 rectangular roll-out fields (replaced in 2009)
3	Rockville SportsPlex	Constructed	2000	3 rectangular fields (replaced in 2008)

*all outdoor fields and permanent indoor fields (non-roll-out) utilize crumb rubber infill

II. County Demand for Quality Rectangular Fields

There are two primary issues facing the current state of rectangular fields in Montgomery County—lack of capacity (not enough fields) and maintaining the quality of existing fields. These issues are faced by both Parks and MCPS, as described below.

Montgomery County Parks' Ballfield Deficit and Maintenance Challenges

Ballfield Work Group & Ballfield Initiatives CIP Project

In January 1999, at the request of the County Council, the Planning Board and Interagency Coordinating Board – Community Use of Public Facilities (CUPF) approved the formation of a Ballfield Work Group to address the acute shortage of ballfields in Montgomery County. The group consisted of various ballfield user groups and staff from Parks, CUPF, MCPS, and the Department of Recreation. This work group existed for five years and initiated several operational and capital improvements to increase ballfield quality and capacity.

Also in 1999, the County Council approved the "Ballfield Initiatives" project in the Parks CIP. The purpose of the project, as stated in the adopted CIP, is: "The project addresses countywide ballfield needs by funding ballfield improvements on parkland, school sites, and other public sites or private properties". The project is still active today and funds $8.2 million of improvements through FY16. This project funded the artificial turf fields at Montgomery Blair and Fairland, in addition to many other projects that increased field availability.

Land Preservation, Parks and Recreation Plan

The Department of Parks prepares a park and recreation needs analysis every five years (most recently completed in 2005) called the Land Preservation, Parks and Recreation Plan (formerly called the Park, Recreation, and Open Space (PROS) Plan). The Plan points to the need for 123 additional athletic fields in the County by the year 2020, of which 73 are full-sized rectangular fields. The Executive Summary of the report is available at:
http://www.montgomeryparks.org/PPSD/ParkPlanning/Projects/LPPRP/LPPRP_2005/LPPRP_Executive_Summary.pdf.

Building and Sustaining High Quality Natural Grass Athletic Fields

The necessary elements to sustain natural turf grass cover on an athletic field fall into three primary categories: **construction, maintenance, and usage**. All three must be carefully controlled, or the natural grass surface will likely become unsatisfactory and unsuitable for organized sports play. In order to sustain a high quality stand of natural turf grass on a field, it must:

1. be designed and constructed properly,
2. be maintained regularly by qualified personnel, and
3. have usage controlled and limited.

If **any one** of the three elements is missing, natural grass cover on the field will deteriorate over time.

In an effort to explore best practices in high quality natural grass maintenance, the Staff Work Group followed the suggestion of the Montgomery County Safe Fields Coalition to interview the turf managers

from the town of Branford, Connecticut and from St. Mary's College in southern Maryland. In addition, the Staff Work Group contacted staff from the Maryland SoccerPlex to gain their insights into maintaining high quality fields in Montgomery County. The SoccerPlex professionally maintains several types of natural and artificial turf fields for competitive use.

Individuals from the Artificial Turf Staff Work Group have spoken with and asked questions of Kevin Mercer, Certified Turfgrass Professional, Superintendent of Grounds, St. Mary's College of Maryland. He indicated that the stadium field at St. Mary's college is scheduled for 150 hours of use per year. This level of use indicated by Mr. Mercer is approximately half of the use of MCPS stadium fields and does not include college football competition. The Staff Work Group members did not feel that the St. Mary's college experience was comparable to what was being asked of natural grass stadium fields in Montgomery County.

Members of the Staff Work Group also spoke with Alex Palluzzi, Director of Recreation, Town of Branford, Connecticut Parks and Recreation Department. While Parks staff heard of various success stories with organic fertilizers and compost, a main factor in maintaining the playability of town fields is control over use. The town Parks and Recreation staff have not maintained or tracked the hours of use on their fields, so it is difficult to obtain an apples-to-apples comparison of field use. The town staff maintains a calendar to block field time for leagues, and the leagues respect and honor the decisions of the town Parks staff in using the fields after inclement weather. In addition, the high school in Branford has an artificial turf field that is used for high school athletic activities. Montgomery County Parks staff has not learned of any new information that would bring new maintenance practices to the management of Parks and school natural grass fields that would improve their durability to support the amount of use currently recorded on Regional Parks or MCPS stadium fields.

The Staff Work Group discussed many issues regarding both natural and artificial turf with Mr. Jerad Minnick, Sports Turf Manager at the Maryland SoccerPlex in Germantown. Mr. Minnick is an expert in the field of turf field maintenance who has experience with high quality natural grass fields for both Major League Baseball and Major League Soccer teams. Mr. Minnick also has extensive experience with the installation and maintenance of high quality natural and artificial turf fields at the Maryland SoccerPlex.

It is important to note that the establishment and care of turf grass across the country is a specialized discipline and is representative of a large industry. Professional sports teams, universities, golf courses, parks & recreation departments, and the lawn care industry all depend on highly qualified professionals to deliver consistently high-performing turf grass surfaces for their intended purpose. Often, there is dire financial consequence associated with the failure of a natural grass surface. A primary resource for professionals involved with natural grass athletic fields is the Sports Turf Managers Association (www.stma.org). Several members within Parks staff responsible for the management of natural grass fields are members of this association and network regularly with other members of the local and national chapters about best practices for management of turf grass in the mid-Atlantic region. They stay current with the latest trends regarding field construction, turf grass cultivars, soil properties, drainage systems, mowing, fertilization, insect control, disease and fungus control, irrigation, topdressing, overseeing, aerating, and the many other practices necessary to sustain high quality natural turf grass on

an athletic field in the mid-Atlantic region. Based on the discussions with staff from Branford, Connecticut, St. Mary's College, and the Maryland SoccerPlex, Parks and MCPS staff did not identify any "silver bullet" practices from these examples that would allow MCPS and Parks to achieve hours of use on natural grass that would be comparable to the hours of use possible on artificial turf. *Note: This report goes into further detail regarding hours of use in the "Playability (Hours of Use)" Section later in this report.*

MCPS' Perspectives on High School Stadium Field Issues

Demands on High School Stadium Fields

Significant time, effort, and money are expended in trying to maintain safe, adequate playing conditions on MCPS high school stadium fields. This expenditure of resources consistently falls short of its goal, primarily because of the intensive wear and tear that result from so many sports and teams sharing high school stadium fields for competitive contests.

Twelve interscholastic athletic teams per high school share the stadium field for games. Including scrimmages, regular season games, and playoff games, approximately 95 contests will be conducted yearly on each of the 25 MCPS high school stadium fields in the fall and spring seasons—2,375 contests system-wide. The twelve school teams that share the stadium field at most MCPS high schools include varsity and junior varsity teams in football, boys' and girls' soccer, boys' and girls' lacrosse, and field hockey. In addition, stadium fields accommodate performances by marching bands, pom-poms, cheerleaders, flags, and majorettes.

A result of the intense use is that stadium fields do not have the opportunity to regenerate growth. High school athletic seasons occur in fall and spring, prime growing seasons for cool weather natural turf grass. With considerable cost and effort, schools can get fields to rebound to some extent at season's end in preparation for the next season. However, fields degenerate at a quicker pace the next season because the grass did not have the proper amount of time or weather conditions to regenerate growth and establish a strong root system. After a game is played in wet or adverse conditions, the field is often damaged, its condition rendered unplayable at best, ruined at worst. Provided that funds are available, the field is resodded or renovated after the season ends, and the expensive cycle begins anew.

At the same time, the growing numbers of community groups, already desperate for field space, do not have access to high school stadium fields that feature lights for late-evening practices and games. Through the use of its artificial turf fields at Richard Montgomery and Walter Johnson high schools, MCPS has created opportunities for additional playing time for community groups on high quality fields to help meet the increasing demands for using high school stadium fields.

Off-Campus Practices

There is a major shortage of rectangular outdoor practice facilities at MCPS high schools. Practice fields are used every day throughout the fall and spring, and their conditions are generally sub-standard. Moreover, because of limited field space, students on 125 MCPS athletic teams who use rectangular fields must drive off-campus on a daily basis in order to practice. Many of these students do not have cars, and many are too

young to drive. Safe transit to practice is an issue. In addition, students practicing off campus lack a nearby facility in which to take refuge in the event of sudden severe weather.

An important advantage of artificial turf fields is that they allow all teams that use rectangular fields to conduct practices on campus. The stadium field becomes a practice facility as well as a game facility, and teams can stagger practices in a fashion that allows teams to remain on campus.

A summary of concerns associated with teams practicing off campus include:

- Transportation—Nearly 2,500 students are driving with other students off campus on a daily basis. The prospect of accidents is a concern.
- Field Conditions/Injuries—Whereas attention has been focused on the adverse field conditions of MCPS stadium fields, practice facilities are generally much worse, especially at off-campus sites that are not maintained, lack irrigation, and are used every day. Practice fields are frequently very hard, rock-laden, and have uneven tufts and divots.
- Severe Weather—Sudden storms are a significant source of concern for off-campus practices. When practicing on campus, students can be brought into the building when severe weather suddenly appears. For off-campus practices, there are limited opportunities for students to find shelter.
- Injuries—There are many potential injuries and emergencies that can arise, medical and otherwise, that require assistance. There are other coaches and athletic personnel located on campus to assist in an emergency situation. This important advantage is lost for teams that practice off campus. All MCPS high schools have an Automated External Defibrillator (AED) located outside, adjacent to practice facilities, in case of an emergency. An AED is not available at off-campus sites.
- Supervision—It is much easier to supervise students at the high school facility, where there are more faculty and staff than at off-campus sites. Supervision concerns include students arriving at the off-campus site at staggered times, in advance of the coach.

Other issues with off-campus practices include:

- Each of the 125 teams that practice off campus practiced an average of 44 times over the season, a total of 5,456 off-campus practices.
- Each team had an average of 20 students, a total of 2,480 students.
- An off-campus practice requires approximately two extra miles of daily driving to get to and home from the off-campus site.
- Estimating two students per car, approximately ten cars travel two miles on 5,456 occasions to take students to off-campus practices at 22 high schools—approximately 109,210 total miles.
- Assuming the average car uses approximately 22.4 miles per gallon (per EPA 11/17/2010 assumptions for 2009 average vehicle fuel economy), approximately 4,875 gallons of gasoline are consumed annually to transport students to off-campus practices.
- According to USEPA calculators, the gasoline used results in approximately 43.3 tons of carbon dioxide emissions each year (http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results).
- Middle and elementary schools frequently voice concern that having high school teams practice at their facilities is disruptive—practices at elementary school sites often begin before school is

dismissed. High school teams prefer to practice relatively soon after school for a multitude of reasons, including that it allows sufficient time for homework.

- Storage—transporting equipment such as practice balls, portable goals, cones, etc., to off-site practices on a daily basis is a major inconvenience.

Equity Issues

The current state of Montgomery County Public Schools (MCPS) high school stadium fields varies greatly across the system. The standard field for MCPS high schools is a native soil field with bluegrass or fescue turf. Some schools, with substantial booster club support, have been able to install Bermuda grass surfaces that require costly annual maintenance contracts. However, most MCPS high schools do not have the financial support from their booster clubs to fund a maintenance contract for a Bermuda grass field, creating a distinct inequity among schools. The conditions of stadium and practice fields are easily the largest factors that differentiate MCPS high school interscholastic athletic programs. Athletic programs are relatively similar in most other respects, including uniforms, officials, and safety equipment. There is a need to provide the same game and practice conditions for all 25 MCPS high schools.

Also, because of inadequate field conditions on the stadium field, field hockey teams do not compete on the stadium field at approximately half of the MCPS high schools, creating an important Title IX issue relating to equal access to facilities. Field hockey teams in one-half of the schools do not have equal opportunity to compete in the school's premier athletic facility.

The inequity in field conditions is most pronounced when comparing practice facilities. Practice facilities at schools that lack the financial means for continuous maintenance are far inferior to schools with more abundant financial means.

Cost of Maintenance

Data compiled for the 2009-2010 school year indicate that the 25 MCPS high schools spent an average of $22,000 to maintain their natural grass fields. However, a closer look at this figure reveals the inequity that exists among MCPS high schools, and also reveals a more realistic estimate for the cost associated with proper maintenance of a high-use athletic field. Briefly, most high schools lack the funds to install and maintain the more expensive Bermuda grass fields. Yet Bermuda surface fields are clearly the fields that are in the best condition.

Though the average field maintenance cost for the 25 MCPS high schools was $22,000, the seven MCPS high schools with the highest annual athletic income for the 2009-2010 school year spent an average of $45,400 for field maintenance. Six of these seven schools have Bermuda grass surface fields.

In contrast, the 15 high schools with the lowest annual athletic income for 2009-2010 spent an average of $13,400 for field maintenance (Montgomery Blair, Walter Johnson, and Richard Montgomery high schools, with artificial turf fields, are not included in this calculation). The disparity between schools is clear. It is also clear that most schools spend far below what is required to maintain a quality stadium field.

Cancellations

Several hundred MCPS games are cancelled or postponed annually because of the condition of natural grass fields. Playing a game on a wet field can ruin the field for the season, rendering the field unplayable and resulting in extremely expensive repairs. It does not necessarily have to be raining for a game to be cancelled or postponed; one sustained rainfall can cause a field to be shut down for many days.

Regular season games are not the only rain-related cancellations that are of concern. Rain also causes hundreds of practice adjustments and cancellations in the course of a year. Practice cancellations and adjustments seriously disrupt student schedules and can have an effect on student conditioning.

Rain-related game and practice cancellations and adjustments have a significant effect on schools, students, parents, game officials, bus drivers, booster clubs, and many others. The adverse effects are not only financial; they also wreak havoc on the day-to-day lives and routines of many people. Cancellations also place schools that do not have artificial turf stadium fields at a decided competitive advantage.

Approximately 30 games at each high school, 750 games system-wide, will be cancelled or postponed in a typical year that could have otherwise been played on an artificial surface field. Similarly, approximately 120 practices per school, 3,000 practices system-wide, will be cancelled or disrupted each year because of rain.

A summary of adverse consequences associated with weather-related game and practice cancellations includes the following:

1. Financial

- Gate Receipts – Gate receipts are collected for all events conducted on the stadium field. Approximately 10 percent of 750 MCPS stadium field contests that are cancelled each year will not be rescheduled, resulting in annual lost gate receipt income of approximately $35,000.
- Referees – Approximately 50% of the 750 games that are cancelled each year on stadium fields are cancelled after teams and referees have arrived on site, an annual expense of about $50,000.
- Transportation – There are expenses associated with obtaining a second bus for rescheduled games. A bus costs about $140 per contest, resulting in an additional annual expense of about $52,000.

2. Game Preparedness and Athletic Conditioning

- It is important that students practice on a regular basis. Regular, consistent practices are necessary for proper conditioning as well as for developing proper technique. Each team that shares the stadium field will have approximately ten practices cancelled or adjusted to a later time, 120 practices per high school, and 3,000 practices system-wide.

3. Disrupted Schedules

- Cancellations and subsequent rescheduling of contests and practices have significant consequences on the schedules and quality of life experiences of thousands of students and their parents.

- When rain causes practices to be rescheduled for the gym, practices are staggered so that several teams may conduct practices. Often the last team does not end practice until 9:00. Generally, students do not know in advance that their practice time will be adjusted, creating conflicts and disruptions, including homework, dinner, babysitting siblings, finding a way to go home and return for practice, etc.
- Rain adjustments cause significant hardships for parents. Athletic game schedules are posted in late July. Many parents will begin planning and arranging their personal and work schedules as early as late July, according to the posted schedule.

4. Competitive Disadvantage

- Cancellations create inequities, resulting in competitive advantages for some schools/teams. Teams achieve higher seeds in playoffs, according to their regular season record. Teams that have an artificial turf field have a distinct advantage over other schools. Not only do they have fewer game cancellations; they also can practice and prepare consistently without interruption.

High School Stadium Fields with Artificial Turf

For Richard Montgomery, Montgomery Blair, and Walter Johnson high schools, there are many benefits associated with artificial turf on their stadium fields. These benefits for both high school and community groups include:

- Providing safer, more consistent, and more competitive surfaces for hundreds of MCPS and community teams.
- Providing safe, on-campus practice areas for MCPS athletic teams and freeing up off-campus practice fields for community use.
- Providing community teams and community groups access to high quality lighted fields that helps to address the documented rectangular field shortage in the County.
- A greater degree of compliance to Title IX. Field hockey contests are not played on the stadium field at approximately half of the MCPS high schools because of unsuitable field conditions.
- Minimal cancellations. Prevailing weather conditions in the fall and spring force many cancellations, disrupting parents' as well as students' schedules. The only weather conditions that would cause a postponement on artificial turf fields would be lightening or abnormally severe weather.
- Significant savings in maintenance. Savings include not only seed, grass, fertilizer, and water, but also an enormous savings in time and effort by school staff and parent volunteers.
- Physical education classes having access to a safe, all-weather surface for activities during the school day for more than half of the school year.
- Reducing the amount of fertilizer, pesticides, and herbicides potentially reaching the Chesapeake Bay. Much attention has been focused on conserving resources and reducing pollutants reaching the Chesapeake Bay. Artificial turf fields require no fertilizer, pesticides, herbicides, or water. They also do not need to be mowed, avoiding another significant pollutant from lawnmower exhaust.
- Creating a greater degree of equity among high schools. The most immediate, visible difference among school athletic programs is the condition of outdoor practice facilities and stadium fields. Schools located in comparatively affluent areas of the County tend to have stadium fields and

practice fields that are far more attractive and that are in far better condition than fields in less affluent areas.

- Creating greater opportunities for physical activities for youths. Childhood obesity is a serious community problem. Because of the paucity of available fields, there are significant limitations on the time available for youth to participate in community field activities.

Injuries and Field Consistency in Natural and Artificial Turf Fields

Comparing artificial turf fields to healthy, vibrant, high quality natural grass fields reveals the two are very close from an injury data perspective. In a five-year intensive study, Meyers and Barnhill (2004) found that while minor and substantial football injuries were slightly more prevalent on artificial turf fields, severe injuries were more prevalent on natural grass fields. Similarly, while there was a greater rate of injuries that resulted in zero days of missed practice or playing time on artificial turf fields, the rate of injuries that resulted in one-to-two days of missed time, and 22 days or more of lost time, were greater on natural grass fields. There were more muscle strains on artificial turf fields, but more ligament tears and concussions on natural grass fields.

Available studies and data do not support that athletes playing on a high quality artificial turf field are fundamentally more or less prone to injury than those playing on a high quality natural grass field. Also, these studies review the injury data for artificial turf fields as compared to natural grass fields that are in ideal condition. Few of the 25 MCPS stadium fields would fit the description of a natural grass field in ideal condition, and none would qualify for comparison at midseason or season's end.

Perhaps the greatest safety advantage of artificial turf fields over typical natural grass fields is their consistency. From a player injury perspective, artificial turf fields compare favorably to a high quality natural grass field in good condition and under optimum weather conditions. However, as weather conditions and field conditions become less than optimal, the safety advantages of artificial turf fields increase significantly. They are not as slippery as natural grass fields in wet conditions, they do not freeze in cold weather, and they do not become hard in dry or drought conditions. They do not develop divots, high spots, and low spots. In short, artificial turf remains consistently uniform, with good traction, no matter what type of shoe. The condition of artificial turf fields is not contingent on expensive and time-consuming maintenance, the extent of their use, or prevailing weather conditions.

III. Playability (Hours of Use)

Comparing the Potential Hours of Use of Natural Grass and Artificial Turf Stadium Fields

A primary reason both Parks and MCPS support the construction of artificial turf fields at sites that meet certain criteria[3] is the increased hours of use possible with artificial turf fields as compared to hours of use with high quality natural grass fields. These increased hours of use are achieved without risking degradation of the field. The increased playability also provides more flexibility for scheduling and co-locating events at a single location. As noted earlier, even under limited hours of use, natural grass fields can suffer major damage from intensive play, especially when play occurs during or immediately after storm events.

In a comparison of natural grass fields and artificial turf fields, it is important to take into consideration hours of use when considering lifecycle costs, as discussed in the next report section, as well as when considering operational and environmental impacts.[4]

A February 2010 study, "Review of the Impacts of Rubber in Artificial Turf Applications", by Rachel Simon of the University of California, Berkeley (Prepared For: The Corporation for Manufacturing Excellence (Manex) Full text available at http://www.fieldturf.com/images/downloads/UC_Berkeley_-_Review_of_the_Impacts_of_Crumb_Rubber_in_Artificial_Turf.pdf) provided this summary of differences in hours of use between natural and artificial turf fields as identified by various sources and prior studies:

> *"The Synthetic Turf Council (2008), an artificial turf advocacy group, estimates that natural fields provide 80-816 hours of play in a three-season year, as compared with 3,000 hours for synthetic turf. Kay and Vamplew (2006) offer an alternative estimate with approximately 300 hours of play time for natural grass, 800 for reinforced turf, and 3,000 for artificial turf. James and McLeod (2008) calculate the usable hours of synthetic turf to be closer to 2,000 hours per year on average, with a range from 450 to 4,200 hours. They also note that the typical weekly hours of use for synthetic turf pitches were 44 hours, as compared to 4.1 hours for natural turf."*

While these ranges all differ, they all point to significantly more hours of use with artificial turf fields. For purposes of this report, the Staff Work Group looked at data specific to natural and artificial turf fields in Montgomery County to provide a more relevant and specific assessment of hours per use for different field types.

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[3] For Parks, the primary criteria are: the ability of the site to handle intense use without conflicts with adjacent communities, adequate parking, and the existence or future capability of lighting. MCPS supports installing artificial turf at high school stadium fields as part of comprehensive high school modernization projects.

[4] For instance, even under the most conservative assumptions in this section, an artificial turf field provides hours of use equivalent to approximately 3 natural turf fields. In other words, to achieve the same programming benefit of one artificial turf field, three natural turf fields would have to be built and maintained.

Artificial Turf Hours of Use

Fortunately, the maximum amount of potential use for the three existing high school stadium artificial turf fields can easily be defined based on their respective warranties (all from FieldTurf Tarkett). The Montgomery Blair High School warranty is presented in Appendix B and includes a specific provision that "Normal and ordinary use is considered as usage up to 3000 hours per year of regular play..."

To estimate actual use at the high school stadium fields, the Staff Work Group looked at several categories of use, including:

- partnership agreements (applicable at the Richard Montgomery High School and Walter Johnson high school fields)[5];
- FY11 community use (identified by CUPF and Parks' permit data);
- estimated use by MCPS after hours (typically for team practices and games); and
- estimated use by MCPS during the school day (based on discussions with athletic directors about how the current artificial turf fields are utilized during the school day for physical education classes).

The following chart summarizes this information by existing artificial turf field:

Chart III-1 Estimated Annual Hours of Use at Existing High School Artificial Turf Fields

	FY11	Comment
Richard Montgomery High School		
- Partnership (Maryland Soccer Enterprises)	856.0	Hours reserved per contract
- Community Use	149	Per CUPF records
- MCPS Use (non-school hours)	700	Estimate for team practices and games
- MCPS Use (school hours)	600	Estimate for PE Use during the schoolyear
Total Estimated Use	**2,305**	
Walter Johnson High School		
- Partnership (Bethesda Soccer Club)	898.5	Hours reserved per contract
- Community Use	74	Per CUPF records
- MCPS Use (non-school hours)	700	Estimate for team practices and games
- MCPS Use (school hours)	600	Estimate for PE Use during the schoolyear
Total Estimated Use	**2,273**	
Blair High School		
- Partnership	n/a	
- Community Use	454	Per CUPF records
- MCPS Use (non-school hours)	700	Estimate for team practices and games
- MCPS Use (school hours)	600	Estimate for PE Use during the schoolyear
Total Estimated Use	**1,754**	
Average Estimated Use (across all three fields)	**2,111**	
Average estimated hours at "partnership" fields	**2,289**	

[5] For the Richard Montgomery High School Field, Maryland Soccer Enterprises (MSE) paid $300,000 up front for up to 856 annual hours of use over five years. This agreement equates to $60,000 in annual revenue and an hourly rate of about $70.00. For the Walter Johnson High School field, only one full fiscal year of data is available. At this field, the Bethesda Soccer Club paid $324,500 up front plus $16,500 per year for four years for up to 898.5 hours of use per year over five years, for an hourly rate of approximately $87.15.

Other non-MCPS field users pay the Community Use of Public Facilities' (CUPF) rate of $125 per hour for non-profit in-county groups and $200 per hour for commercial and out-of-county groups. Note: On January 1, 2011, CUPF assumed programming responsibilities for the Blair High School field.

For FY11, the two fields with private partnership agreements achieved an estimated 2,300 hours of overall use and close to or above 1,000 hours of community/partnership use.

Blair High School, which does not have a partnership agreement, was utilized an estimated 1,754 hours in FY11, with 454 hours of community use. Since MCPS utilizes the field after school hours for approximately 700 hours per year (including during some prime rental hours), some additional community use could be expected if MCPS' hours were not reserved.

The Staff Work Group also obtained information from the Maryland SoccerPlex regarding hours their three artificial turf fields are open and utilized annually. The artificial turf fields at the SoccerPlex are each available for rental over 3,400 hours per year, and each is used about 1,800 hours per year.

Based on the above information regarding actual and potential hours of use, the Staff Work Group believes assuming 1,000 hours of community use at the MCPS stadium fields as well as at a dedicated Parks artificial turf field (i.e., no shared use with MCPS) is reasonable.

Natural Grass Fields

In most cases, MCPS high schools restrict the use of stadium fields to team games – approximately 300 hours per year. However, some schools with Bermuda grass native soil fields allow some limited physical education programming. In these cases, the fields are used a total of an estimated 400 hours per year.

For Parks, the Staff Work Group looked at the programming experience for the Ridge Road lighted natural grass rectangular field (a cool season native soil field). This field is utilized approximately 500 hours per year. However, according to Parks Staff, the field often exhibits severe wear patterns. Therefore, while the hours of use obtained are greater than the hours at an MCPS field, the quality of the field is far less. Therefore, in comparing the Ridge Road field to an artificial turf field or a high quality sand base Bermuda field, one must take into account the field condition and the reduced fee one can charge for the field as a result. Revenue generation is discussed in the next section of this report.

The Maryland SoccerPlex limits usage on its natural grass fields to between 400 hours and 600 hours per year. It is important to note that the Maryland SoccerPlex does not program football (the most damaging sport for natural grass fields) and has a very different scheduling profile (year-round but less intensive use) than MCPS as well as an on-site centralized maintenance program run by expert professional staff.

Hours of Use Comparison Chart

The following chart presents four ways to calculate the difference in hours of use of an artificial turf field versus a natural grass field.

1. The potential hours of use of an artificial turf field are assumed to be 3000 hours per year, based on staying within the warranty coverage provided for in the Montgomery Blair High School warranty. The top portion of the chart shows the total hours the MCPS artificial turf fields could theoretically be open and then deducts hours to take into account lack of MCPS use in cold-weather months, reduced use during peak hot weather times, and other miscellaneous hours of non-use, even if one were to achieve a maximum 3000 hours of use. This number is then

compared to MCPS' current standard stadium field use (300 hours per year) and then also to a higher usage rate (600 hours) that might be possible with a higher quality natural grass field.

2. The hours of use of an MCPS artificial turf stadium field are calculated based on actual and estimated hours of community and MCPS use as discussed earlier. This number is then compared to MCPS' current stadium field use for its natural grass fields (300 hours per year) and then also to a higher usage rate (600 hours) that might be possible with a higher quality natural grass field.

3. The hours of use of an artificial turf field are calculated based on the potential hours of use (3,000 hours) and the projected hours of use for an exclusive Parks field (no high school use). These numbers are then compared to actual hours of use (500 hours) Parks obtains from a typical lighted full-size rectangular field (Ridge Road Park, for example). As noted earlier, Parks staff has noted that in the Ridge Road Park example, the field often exhibits severe wear patterns, even at this limited level of use.

4. The hours of use of an artificial turf field are calculated based on potential hours (3,438) and actual hours (1,800) of programming of each of the Maryland SoccerPlex artificial turf fields. These numbers are then compared to the maximum hours of use for the Maryland SoccerPlex's natural grass fields, according to Maryland SoccerPlex staff.

Chart III-2: Artificial Turf Field Annual Hours of Use Calculation for MCPS and Parks Ballfields

		Hours			Assumptions
1	**Potential Hours of Programming Based on Current MCPS Schedule**				
	Maximum Hours Available Annually	4,928			Hours: 8:00 AM to 9:30 PM, 365 days per year
	Subtract for limited cold weather use*	(1,080)			Community Use only. No MCPS practices or games assumed for 120 days.
	Subtract for no use during peak heat hours	(480)			Exclude an average of 6 hours per day for 80 days
	Subtract for other potential unavailable times	(368)			Reduce usage to 3000 hours (max allowed under the Blair/RM HS warranties)
	Net Hours Programmable	**3,000**			
	Ratio to Current MCPS Natural Grass Fields	10.0	to	1	Assumes 300 hours of use maximum per year on natural grass fields
	Ratio to Improved MCPS Natural Grass Fields	5.0	to	1	Assumes 600 hours of use maximum per year on natural grass fields
2	**Estimated Hours of Use Based on Richard Montgomery High School, Walter Johnson, & Blair High School Field Experience**				
	Community/Partnership Use	1,000			
	High School Use for team practices/games	700			
	Physical Education Class Use	600			
	Estimated Usage	**2,300**			
	Ratio to Current MCPS Natural Grass Fields	7.7	to	1	Assumes current 300 hours of maximum use per year on natural grass fields
	Ratio to Improved MCPS Natural Grass Fields	3.8	to	1	Assumes current use could be expanded to 600 hours of use per year
3	**Potential and Projected Programming for Artificial Turf Fields at Parks Facilities**				
	Potential Hours of Use	3,000			Maximum allowed under the Blair/RM HS warranties
	Ratio to Current Parks Natural Grass Fields	6.0	to	1	Assumes current 500 hours of maximum use per year on natural grass fields
	Ratio to Higher Quality Parks Natural Grass Fields	5.0	to	1	Assumes current use could be expanded to 600 hours of use per year
	Estimated Use	1,000			Assumed to be similar to community/partnership use experience at MCPS AT fields
	Ratio to Current Parks Natural Grass Fields	2.0	to	1	Assumes current 500 hours of maximum use per year on natural grass fields
	Ratio to Higher Quality Parks Natural Grass Fields	1.7	to	1	Assumes current use could be expanded to 600 hours of use per year
4	**Hours of Programming at the Maryland Soccerplex**				
	Total Hours Programmable	3,438			Hours fields are available for rent**
	Ratio to Current Natural Grass Fields	6.9	to	1	Assumes 500 hours of use max. per year on Kentucky bluegrass native soil fields
	Ratio to Improved Current Natural Grass Fields	5.7	to	1	Assumes 600 hours of use max. per year on Bermuda grass fields
	Actual Programming	1,800			Actual utilization
	Ratio to Current Natural Grass Fields	3.6	to	1	Assumes 500 hours of use max. per year on Kentucky bluegrass native soil fields
	Ratio to Improved Current Natural Grass Fields	3.0	to	1	Assumes 600 hours of use max. per year on Bermuda grass fields

*AT fields are sought after by private groups during cold weather months, since natural grass fields are often not playable at these times.

**Includes weekend days & nights year round, weeknights (non-summer months) and weekdays and weeknights (summer months)

Findings:

1. At the 3,000 hour cap, the hours of use of an artificial turf field would be ten times the current usage (300 hours) of MCPS natural grass stadium fields. If natural grass stadium field maximum usage could be doubled to 600 hours per year, the ratio for maximum potential use would still be five times that of natural grass stadium fields.

2. The actual ratio of usage at MCPS' high school stadium fields (an estimated 2,300 hours per year) is 7.7 times the current usage of MCPS' natural grass stadium fields. If natural grass stadium field usage could be increased to 600 hours per year, the ratio would still be 3.8 times more usage on artificial turf stadium fields.

3. A Parks artificial turf field would be utilized less than a schools field (no MCPS use during the day). However, the community use alone would be about twice as much as is obtained now with a native soil field that exhibits severe wear patterns. If natural grass stadium field usage could be increased to 600 hours per year, the ratio would be about 1.7 times more usage on artificial turf stadium fields. As noted in the chart, with an artificial turf field, Parks also has the opportunity to greatly increase its programming hours. Given the wear exhibited at its natural grass fields, even at the limited hours in place now, increases in hours of use at its natural grass fields would risk even more substantial field degradation.

4. The Maryland SoccerPlex's artificial turf fields are utilized about 1,800 hours per year. This compares to approximately 500 to 600 hours of programming at its natural grass fields, resulting in ratios of 3.6 to 1 and 3.0 to 1 respectively. As noted for the Parks fields, the Maryland SoccerPlex has additional potential capacity at its artificial turf fields that it does not have at its natural grass fields (due to concern over field degradation).

IV. Lifecycle Cost Evaluation

A key factor in deciding whether to build an artificial turf field or a natural grass field is the comprehensive lifecycle costs (construction, maintenance, revenue, rehabilitation, replacement), including the cost per hour of use. The cost per hour of use is based on the estimated annual hours of use one can expect from the different field types, based on the programming expected for the field.

The Staff Work Group chose four natural grass field types to compare to a typical artificial turf field. The four natural grass field types consist of two different field bases (a 10 inch sand base and a native soil base) and two different grass types (Bermuda grass and Cool Season/Kentucky Bluegrass). The artificial turf field is assumed to be a polypropylene carpet with a crumb rubber infill.

Sand Base and Native Soil Fields

A sand base field is built on a 10"-12" deep profile of sand. Under the sand is a 4" layer of pea gravel that is lined with drainage tile on 15' centers to move the water that drains through the sand and into the gravel away from the field. Sand base fields cost substantially more to build than native soil fields but provide two major advantages:

- Fewer Rain Outs: Water drains through the profile quickly, leaving no standing water and eliminating puddles or muddy field conditions.
- Increased Hours of Use: A sand base is a mix of specific grades, angles, and sizes of sand. Because of the mix, sand will not compact nearly as quickly as a native soil field will from foot and mechanical traffic. Since compaction is a large factor in a field thinning out and dying, a sand base allows more play than a native soil field before it begins to thin out.

A native soil field is a field constructed of the soil profile native to the area where the field was built. Soil amendments can be added to native soil to make it perform better for sports fields. Native soil will not give the performance on drainage and compaction that sand will (unless the native soil happens to meet the particle size analysis that is specified for a sand base). A native soil field is significantly less expensive than a sand base field, but does not provide the same advantages of a sand base field noted above.

Bermuda Grass and Cool Season Grass Fields

Bermuda grass is a "warm season" type grass that is being grown in areas as far north as Philadelphia, PA. Bermuda grass is native to the warm weather climates of the south, but genetic and breeding technology has allowed the grass to be successfully used further north into the climate region of Maryland. The grass grows actively during the warm weather months of June through September. Bermuda grass turns brown and is dormant from October through mid May. Bermuda grass takes small amounts of pesticides to maintain and requires less fertilizer than "cool season" turf grasses, but requires more frequent mowing and lower mowing heights to maintain a high quality stand. Bermuda grass is more problematic in northern parts of the country because the cold winters will cause the grass to "winter kill".

Cool season turf grass grows actively during the months of April through June, then September through mid-November. Cool season turf varieties for sports fields are typically Kentucky bluegrass and mixed

grasses including Kentucky bluegrass with Fescue and/or Ryegrass. Cool season turf grass grows more slowly than Bermuda grass and requires more fertilizer and more pesticides, but requires less mowing. Cool season turf grass is limited in its use much further south because the high temperatures of summer cause the turf to go dormant and raise the potential for disease killing out large amounts of turf.

Current Examples of Fields in Montgomery County

The Staff Work Group believes the closest "apples to apples" comparison in terms of field quality between natural and artificial turf fields is a sand base Bermuda grass or sand base Kentucky bluegrass field to a current generation artificial turf field. However, the Staff Work Group also included two native soil field examples in its comparison (Bermuda and Cool Season), since both types of fields are currently in use in Montgomery County by Parks, the Maryland SoccerPlex, and/or MCPS.

M-NCPPC Parks has 18 regional/recreational park rectangular fields. Thirteen of these fields are bluegrass or fescue on native soil, three are Bermuda grass fields on native soil, and two fields are artificial turf with crumb rubber infill.

The Maryland SoccerPlex manages 20 rectangular fields. Fourteen of these fields are Kentucky bluegrass on native soil, one field (the championship stadium field) is Kentucky bluegrass on a sand base, two fields are Bermuda grass on native soil, and the remaining 3 fields are artificial turf with a crumb rubber infill.

MCPS has 25 stadium fields (including Montgomery Blair High School). Twelve of these fields have bluegrass or fescue on native soil. Ten fields have Bermuda grass on native soil and three stadium fields are artificial turf with crumb rubber infill.

Comparison of Natural and Artificial Turf Athletic Fields – Major Assumptions[6]

- A high quality playing surface is to be provided, sufficient for high school and adult level competitive team sports.
- Usage is controlled at all times (i.e., the field is secured; there is no walk-on usage).
- The field is designed and constructed by qualified professionals according to industry standards.
- The field is maintained by qualified professionals year-round according to industry standards. The maintenance practices are consistent with the hours of use assumed for each type of field.
- The hours of use for each of the natural grass fields are capped (see previous report section) to avoid degradation of a field from overuse. For this analysis, hours of use assumptions are based on the actual hours of play experienced at MCPS stadium fields, Parks fields, and the Maryland SoccerPlex fields.
- The artificial turf field comparison for MCPS assumes annual hours of use based on actual hours programmed at the existing artificial turf fields at Montgomery Blair High School and Richard Montgomery High School. As previously noted, the hours of use could potentially be expanded to as much as 3,000 hours per year without voiding existing warranties for those fields.
- The artificial turf field comparison for Parks fields assumes 1,000 hours of community use at each artificial turf field.

[6] See Appendix D for details.

- A 20 year time horizon was chosen for the lifecycle analysis. This time period is long enough to assume two carpet replacements for the artificial turf field and one major renovation of each natural grass field.[7]
- **Construction Costs (see Appendix D for cost details)**
  - For the artificial turf fields, costs are an average of actual costs incurred for the Montgomery Blair, Richard Montgomery, and Walter Johnson high school stadium fields. A substantial allowance ($300,000) is included for stormwater management for the artificial turf fields. However, these and other costs will depend greatly on specific site conditions and could be less costly for MCPS, since MCPS' stadium fields are constructed as part of a larger school modernization project.
  - For the natural grass fields, construction cost estimates are based on information provided by staff of the Maryland SoccerPlex.
- **Maintenance Costs** - The Staff Work Group asked staff of the Maryland SoccerPlex to provide typical maintenance practices to assume to maintain a high quality playing surface for the different types of fields. Actual maintenance practices will vary based on specific field conditions, weather patterns, resources available, labor costs, the knowledge and skills of the turf manager, and other factors. Please see Appendix C for a summary of lifecycle cost maintenance assumptions. For purposes of this analysis, the following annual maintenance costs were derived based on knowledge of best practices by SoccerPlex staff and actual costs incurred by MCPS currently for its various fields[8].
  - Cool season grass native soil field: $25,000 per year
  - Bermuda Grass native soil field: $45,000 per year
  - Sand Base Field (Bermuda or Kentucky Blue grass): $50,000 per year
  - Artificial Turf Field: $10,000 per year
- **Revenues**
  - Artificial turf field assumption = $80,000 per year. Depending on the revenue model assumed for the artificial turf ballfield, this assumption equates to 1,000 hours of total partnership/community use at an average rate of $80 per hour or 640 hours of community use at the CUPF rate of $125 per hour. Actual revenue will depend on whether a private sector partner is involved (and the effective hourly rate negotiated) and/or the actual community use hours booked.
  - Natural grass fields = No revenue is assumed for MCPS' natural grass stadium fields, since these fields are reserved for MCPS use only. For Parks' natural grass fields, revenue is based on estimated hours of use times an hourly rate. For sand base fields, the hourly rate is assumed to

[7] The carpet is assumed to be recycled at a cost of $75,000. This number is based on a cost of $0.75 per square foot for a 100,000 square foot field (per FieldTurf Tarkett). The crumb rubber and sand are assumed to be reused.

[8] Cool season annual maintenance cost based on a full-service contract. For Bermuda grass fields on native soil, the costs are based on average contract costs incurred for Churchill, Quince Orchard, and Walt Whitman high schools. For sand base fields, costs are based on discussions with staff from the Maryland SoccerPlex. Artificial turf field costs assume an annual maintenance contract with an artificial turf vendor (this cost is $6,800 per year for the Richard Montgomery High School field) plus estimated regular maintenance hours performed by the high school Athletic Director (40 hours per year at $25 per hour = $1,000). The maintenance cost was then conservatively rounded up an additional $2,200 (to $10,000) to accommodate potentially higher per hour costs and/or additional maintenance needs.

be comparable to a rate achieved at the artificial turf fields through a partnership agreement ($80). For native soil fields, existing Parks field rates are assumed.

Lifecycle Cost Analysis

Below are two summary charts (one for MCPS and one for Parks) showing the 20 year lifecycle cost and per hour cost for each type of field. The major differences between the two charts are the 20 year revenue assumptions for the natural grass fields and the hours of use assumed for the natural and artificial turf fields (as discussed in Section III). MCPS does not currently permit its stadium fields (whether Bermuda or cool season grass) for outside use and the lifecycle cost summary assumes there would be no revenue collected from any future natural grass fields constructed. The revenue numbers for Parks assume that the sand base fields could be permitted at hourly rates comparable to the rates currently charged for artificial turf fields by CUPF. Hourly rates for the native soil fields are assumed to be the same as Parks currently charges for its regional rectangular fields.

Chart IV-1: 20 Year Cost Summary - MCPS

		Artificial Turf	Bermuda (Sand Base)	Kentucky BG (Sand Base)	Bermuda (native soil)	Cool Season (native soil)
20 Year Net Costs	Initial Capital Cost	1,125,000	530,000	580,000	150,000	75,000
	20 Year Replacement/Rehab Cost*	1,280,000	150,000	175,000	100,000	60,000
	20 Year Maintenance/Other Costs	206,000	1,000,000	1,000,000	900,000	500,000
	20 Year Total Costs	**2,611,000**	**1,680,000**	**1,755,000**	**1,150,000**	**635,000**
	20 Year Revenue - MCPS**	1,600,000	-	-	-	-
	20 Year Net Cost - MCPS	**1,011,000**	**1,680,000**	**1,755,000**	**1,150,000**	**635,000**
	20 Year Net Cost - Net Present Value					
	3 Percent Discount Rate	933,158	1,363,644	1,429,722	885,255	486,835
	5 Percent Discount Rate	894,795	1,211,398	1,272,938	759,340	416,394
	7 Percent Discount Rate	863,930	1,091,630	1,149,459	661,319	361,585
Cost Per Hour of Use	**Annual Hours of Use**	**2,300**	**600**	**500**	**400**	**300**
	20 Year Net Cost Per Hour of Use - MCPS	**21.98**	**140.00**	**175.50**	**143.75**	**105.83**
	3 Percent Discount Rate	20.29	113.64	142.97	110.66	81.14
	5 Percent Discount Rate	19.45	100.95	127.29	94.92	69.40
	7 Percent Discount Rate	18.78	90.97	114.95	82.66	60.26

*Assumes two artificial turf carpet replacements (after years 8 and 16) and one major natural grass rehab after year 12.

**No revenue assumed for natural grass fields since MCPS would reserve these fields only for MCPS team games and practices.

Findings – MCPS Stadium Fields:

- Artificial turf fields cost approximately twice as much to construct as either of the sand base fields.
- The least expensive field, by far, over a 20 year period is the cool season grass native soil field.
- However, revenue generation is an important factor in the analysis. When taking into account revenue generated (this analysis assumes $80,000 per year for artificial turf), the net cost of artificial turf fields is below the net costs for all of the other fields except the cool season native soil field.

- Because of the high up-front costs for artificial turf and sand base natural grass fields, a net present value calculation increases the net costs of these fields (over a 20 year time horizon) in comparison to the native season natural grass fields. However, the sand base fields still have a much higher net cost than the artificial turf fields.
- Despite the higher up-front and future replacement costs, an artificial turf MCPS Stadium field provides a substantially lower net cost per hour of use than any of the natural grass options because of the substantially increased hours of use and additional revenue generated from that increased use.
- Assigning various discount rates to the hours of use partially reduces the hours of use cost disparity, but the artificial turf field still has a much lower cost per hour of use than all of the other fields.

Chart IV-2: 20 Year Cost Summary - Parks

		Artificial Turf	Bermuda (Sand Base)	Kentucky BG (Sand Base)	Bermuda (native soil)	Cool Season (native soil)
20 Year Net Costs	Initial Capital Cost	1,125,000	530,000	580,000	150,000	75,000
	20 Year Replacement/Rehab Cost*	1,280,000	150,000	175,000	100,000	60,000
	20 Year Maintenance/Other Costs	206,000	1,000,000	1,000,000	900,000	500,000
	20 Year Total Costs	**2,611,000**	**1,680,000**	**1,755,000**	**1,150,000**	**635,000**
	20 Year Revenue - Parks**	1,600,000	960,000	800,000	280,000	220,000
	20 Year Net Cost - Parks	**1,011,000**	**720,000**	**955,000**	**870,000**	**415,000**
	20 Year Net Cost - Net Present Value					
	3 Percent Discount Rate	933,158	649,525	834,623	676,971	323,183
	5 Percent Discount Rate	894,795	613,212	774,450	584,869	279,310
	7 Percent Discount Rate	863,930	583,117	725,698	513,003	245,050
Cost Per Hour of Use	**Annual Hours of Use**	**1,000**	**600**	**500**	**500**	**500**
	20 Year Net Cost Per Hour of Use - Parks	**50.55**	**60.00**	**95.50**	**87.00**	**41.50**
	3 Percent Discount Rate	46.66	54.13	83.46	67.70	32.32
	5 Percent Discount Rate	44.74	51.10	77.44	58.49	27.93
	7 Percent Discount Rate	43.20	48.59	72.57	51.30	24.51

*Assumes two artificial turf carpet replacements (after years 8 and 16) and one major natural grass rehab after year 12.
**Natural Grass Revenue = same $ rate as AT for sand-based fields, current rates ($22/hr assumed for native soil fields

Findings – Parks Fields:

- The lifecycle cost results for the various fields are different for Parks than for the MCPS stadium field scenario because all Parks fields are assumed to generate some revenue and the dedicated artificial turf field is assumed to be used fewer hours (only 1,000 hours of community use) as compared to MCPS stadium fields (2,300 hours).
- When taking into account revenue generated (based on the hours assumed above), the net costs of the native soil fields (Bermuda and cool season grass) have the lowest net cost. The artificial turf field has the highest net cost. However, this result would change substantially if hours of use at the artificial turf field increased beyond 1000 hours or if the hourly rate collected for those hours is higher than the $80 per hour assumed. As noted earlier, the potential hours of use of an artificial

turf field are substantially higher than assumed in this lifecycle analysis. For instance, the Maryland SoccerPlex, which operates on a similar schedule to Parks, achieves about 1,800 hours of use out of each of its artificial turf fields. Conversely, the natural grass hours of use shown are assumed to be a maximum that could be achieved, and some field degradation (as noted in the Ridge Road Field example) may occur even at these usage levels.

- Because of the high up-front costs for artificial turf and sand base natural grass fields, a net present value calculation increases the costs of the artificial turf fields (over a 20 year time horizon) in comparison to the other fields.
- On a 20 year net cost per hour basis, the cool season native soil field is the lowest cost option. The next lowest cost option is the artificial turf field.
- Assigning various discount rates to the hours of use increases the artificial turf field cost as compared to the other field types.

Findings – Summary:

In the case of MCPS' stadium fields, artificial turf fields are utilized far more than MCPS' natural grass stadium fields and therefore provide a substantially lower cost per hour of use.

For Parks, the lifecycle cost analysis is more mixed. At the hours of use assumed in the lifecycle analysis, natural grass options may offer a lower long-term cost. However, if increasing the hours of programming above current levels is a goal, then artificial turf offers more potential hours of use. In turn, if community use is increased above the 1,000 hours of use assumed in the lifecycle analysis, the cost per hour would be reduced substantially.

V. Public/Human Health Concerns

Summary

Environmental impact assessments and health impact assessments are formal processes through which the evaluation of our built environment and its impact on human health can be measured. These processes identify and examine potential health risks linked to the environment of concern.

In the absence of either an environmental impact assessment or a health impact assessment on the installation and use of artificial turf fields, the Staff Work Group identified some of the areas of potential human risks that were raised during the compilation of information that forms this report. This is not a complete set of risks. A formal process would be required to identify and examine all the human health risks from all the artificial turf field materials under consideration. Such an analysis was beyond the scope and capacity of the Artificial Turf Staff Work Group.

Due to the distinct physical characteristics of crumb rubber infill artificial turf systems, concern has been raised over potential adverse health effects related to use of these systems. The potential physical health effects associated with crumb rubber infill artificial turf systems include:

- chemical exposures
- heat-related illnesses
- abrasions/turf burns
- injuries
- infections and allergic reactions

The potential for chemical exposure was addressed in most of the literature and reports this committee found. The risk arises from the recycled crumb rubber infill that is part of the most common artificial turf systems. The composition of this crumb rubber is quite variable within and between manufacturers of both natural and synthetic rubbers, including additives such as zinc, lead, sulfur, carbon black, polyaromatic hydrocarbons, and volatile organic compounds. Exposures of concern include physical contact through ingestion, inhalation, and dermal or ocular exposure.

Most of the literature reviewed by the committee also raised the issue of heat-related illnesses from use of artificial turf systems. Artificial turf surfaces are known to absorb heat to a greater degree than natural grass, resulting in surface temperatures that can be much higher than temperatures of the surrounding air. There are claims that the elevated temperatures increase the risks of heat-related illness and complaints of discomfort and actual burns. Please see the next section of this report for a discussion of heat-related issues.

The issue of the types and frequencies of injuries on artificial turf compared to the frequencies and types of those that occur on natural grass surfaces also came up in the literature. Many factors influence the rates of sports injuries, including the type of playing surface. The many kinds of artificial turf surfaces and changes in the products over the years have complicated the assessment of how the playing surface affects injury rates. Also, there are claims that the abrasiveness of artificial turf fibers may contribute abrasions or "turf burns".

Concerns were noted in literature over the potential for bacterial infections, including *methicillin-resistant Staphylococcus aureus* (MRSA), due to the number of abrasions experienced on artificial turf surfaces.

Latex allergies related to contact with artificial turf surfaces that may have latex in their composition also were noted in literature. Latex allergens are found in tire rubber, and players on these fields could be exposed.

The DHHS staff has provided the following comments regarding Artificial Turf:

> *"There are many considerations to weigh in selecting the material with which to construct athletic fields. DHHS is not equipped with the necessary specialized expertise to conduct an environmental and safety assessment of either the artificial or natural grass already in place or to determine what material to use in the future. If this type of assessment is sought, DHHS recommends the county seek outside consultation from an entity with expertise and demonstrated experience in the field. At a minimum, a meta-analysis of all studies should be completed to ensure a complete literature review in this area and it should be done by an entity with a proven topic expertise and track record.*
>
> *The DHHS can assist Parks and MCPS in ensuring that policies and procedures that maximize the level of safe and healthy use and exposure related to athletic field use are based on sound scientific and public health merit and that the policies and procedures align with best public health practices to minimize risk.*
>
> *There are various sources of information on materials that are used to construct athletic fields. Information is available from the natural grass and artificial industries, various government agencies at the federal and state level, academic research, as well as from advocacy groups. The compilation of articles and reports reviewed by the committee was limited to those materials that were easily accessible to the group from independent searches or by recommendations from other interested parties. The articles and reports compiled are not a comprehensive examination of all scientifically sound results-based information of proposed field materials based on the latest scientific research that weighs the strengths and limitations of the material, the evaluation methods or the applicability of the results to the specific conditions in Montgomery County under which the installation, maintenance, and exposures would occur.*
>
> *To fully understand the specific risks with materials installed in Montgomery County, objective testing of the materials used to compile the surfaces being proposed would be required. Outside of general guidance on proposed evaluation strategies and considerations identified from other jurisdictions, the evaluations are interesting, informative but are limited to the area studied in the evaluation."*

Synopses of the reports reviewed by the Staff Work Group

Government Reports

United States Consumer Product Safety Commission

- CPSC Staff Finds Synthetic Turf Fields OK to Install, OK to Play On, U.S. Consumer Product Safety Commission, Office of Information and Public Affairs, Washington, D.C., Press Release #08-348, July 30, 2008. http://www.cpsc.gov/cpscpub/prerel/prhtml08/08348.html

  "CPSC staff evaluation showed that newer fields had no lead or generally had the lowest lead levels. Although small amounts of lead were detected on the surface of some older fields, none of these tested fields released amounts of lead that would be harmful to children.

  Lead is present in the pigments of some synthetic turf products to give the turf its various colors. CPSC staff recognizes that some conditions such as age, weathering, exposure to sunlight, and wear and tear might change the amount of lead that could be released from the turf. As turf is used during athletics or play and exposed over time to sunlight, heat and other weather conditions, the surface of the turf may start to become worn and small particles of the lead-containing synthetic grass fibers might be released. The CPSC staff considered in the evaluation that particles on a child's hand transferred to his/her mouth would be the most likely route of exposure and determined young children would not be at risk.

  Although this evaluation found no harmful lead levels, CPSC staff is asking that voluntary standards be developed for synthetic turf to preclude the use of lead in future products. This action is being taken proactively to address any future production of synthetic turf and to set a standard for any new entrants to the market to follow.

  As an overall guideline, CPSC staff recommends young children wash their hands after playing outside, especially before eating."

United States Environmental Protection Agency

- A Scoping-Level Field Monitoring Study of Synthetic Turf Fields and Playgrounds, Office of Research and Development, National Exposure Research Laboratory, United States Environmental Protection Agency, November 2009. Document available at: http://www.epa.gov/nerl/features/tire_crumbs.html, last modified December 3, 2009.

  This study collected air, wipe, and material samples. The air samples were analyzed for particulate matter mass, metals, particulate morphology and 56 volatile organic analytes. The wipe and material samples were analyzed for total extractable concentrations of several metals and bioaccessible lead. The EPA report concluded:

  "On average, concentrations of components monitored in this study were below levels of concern; however given the very limited nature of this study (i.e., limited number of components monitored, samples sites, and samples taken at each site) and the wide diversity of tire crumb material, it is not possible to reach any more comprehensive conclusions without the consideration of additional data."

State of California

Safety Study of Artificial Turf Containing Crumb Rubber Infill Made From Recycled Tires: Measurements of Chemical and Particulates in the Air, Bacteria in the Turf, and Skin Abrasions Caused by Contact with the Surface, Contractor's Report produced under contract by: California Department of Resources Recycling and Recovery, Office of Environmental Health Hazard Assessment Pesticide and Environmental Toxicology Branch; Sacramento, CA.; October, 2010.
http://www.calrecycle.ca.gov/Publications/Tires/2010009.pdf

The goal of this study was limited to the assessment of inhalation and skin infection risks associated with the use of crumb rubber infill. Specifically, the study looked at the potential for inhalation of volatile organic compounds and particulates less than 2.5 microns in the air above the playing field. With respect to skin infections, the study assessed the harboring of bacteria in the turf and potential for increased skin abrasions.

The study concluded no public health concern was identified with particulates suspended in the air above the playing field and, although volatile organic compounds were detected above the artificial turf surface,...

> *"exposures were below health-based screening levels, suggesting that adverse health effects were unlikely to occur in persons using artificial turf."*

Regarding skin infections, fewer bacteria were detected on artificial turf than on natural grass on those fields tested. The rate of abrasions was two-to-three-fold higher for college soccer players competing on artificial turf as compared to natural grass. It was concluded that the sum effects on the skin infection rate between the two types of turf could not be predicted from the data alone, and additional studies were needed.

The report also acknowledged a number of uncertainties, and data gaps remained that were not controlled in the studies.

NOTE: Subsequent to the release of the Working Group's Draft Report, a "Report to the Legislature" was provided which summarized the results of the report and also provided the following discussion and recommendations:

> *"The results of this research suggest artificial turf fields pose a generally low risk to human health. The VOC analysis determined the chemicals attributable to the artificial turf fields are below the health risk screening levels. The inhalable particulate matter analysis shows a small amount of this material above the artificial turf field and upwind of the field. Furthermore, the elemental composition of the PM2.5 material collected from both above and upwind of artificial turf is similar; suggesting the source of this inhalable particulate matter is something other than the artificial turf fields. For the skin abrasion analysis, while a higher number of skin abrasions occurred on artificial turf fields than on natural turf fields, the severity of those abrasions was similar. For the bacterial analysis, there were fewer bacteria detected on artificial turf compared to natural turf. When taken together, the data from this study do not indicate any significant public health concerns associated with artificial turf fields containing crumb rubber infill from recycled tires, with the possible exception*

of an elevated risk of skin abrasions. Based on these findings from the OEHHA final report, CalRecycle recommends that no additional study or action is warranted regarding potential human health impacts associated with the new generation of artificial turf fields."

City of San Francisco, CA

San Francisco Synthetic Playfields Task Force Findings and Department Recommendations, San Francisco, CA, 2008. http://www.superfill.net/dl010808/SFParks_Playfields_8.21.08.pdf

"The task force identified 11 environmental and health issues of public concern, and for which there was thought to be readily available research. Study teams, comprised of subject matter experts and park users, were assigned to review the research on each issue, synthesize the findings, discuss strengths and weaknesses of the research, assess the relevance of the research to San Francisco's playfields implementation, and, identify suggestions and recommendations for Department staff to make to the Commission."

In February 2008, the San Francisco Department of Health (SFDPH) summarized their review of several reports, studies, and documents relevant to assessing the potential for health risks associated with artificial turf and while often noting that additional research is recommended, they concluded,

"At this time SFDPH does not recommend a moratorium on the continued installation and use of artificial turf playfields in San Francisco. It may be helpful to perform air monitoring on artificial turf playfields in San Francisco during hot weather to help further assess relevant exposures to users in the breathing zone."

State of Connecticut

- Result of State Artificial Turf Fields Study: No Elevated Health Risk, State of Connecticut, Department of Environmental Protection, Hartford, Ct., July 30, 2010. All associated final reports available at: www.ct.gov/dep/artificialturf.

  This collection of studies explored the possible exposures when playing sports on artificial turf fields cushioned with crumb rubber infill. These studies found rubber is a complex mixture of various chemicals, with some having toxic and carcinogenic properties. Exposure is possible, primarily via inhalation, given that chemicals emitted from rubber can end up in the breathing zone of players and these players have high ventilation rates. Rainwater may leach chemicals from the rubber into underlying groundwater or nearby streams, and there is a potential risk to surface waters and aquatic organisms associated with whole effluent and zinc toxicity of stormwater runoff from artificial turf fields. These reports were peer reviewed by the Connecticut Academy of Science and Engineering, and comments were incorporated into the final report.

  With respect to the five fields tested in Connecticut, the report concluded:

  "Based upon these findings, the use of outdoor and indoor artificial turf fields is not associated with elevated health risks. However, it would be prudent for building operators to provide adequate ventilation to prevent a buildup of rubber-related VOCs and SVOCs at indoor fields. The current study did not evaluate new fields under hot weather conditions and so the potential for

acute risks under this circumstance is another uncertainty. The current results are generally consistent with the findings from studies conducted by New York City, New York State, the USEPA and Norway which tested different kinds of fields and under a variety of weather conditions. Thus, it appears that the current results are reasonably representative of conditions that can be encountered at indoor and outdoor crumb rubber fields, although this tentative conclusion could benefit from the testing of additional fields."

State of New York

- An Assessment of Chemical Leaching, Releases to Air and Temperature at Crumb-Rubber Infilled Synthetic Turf Fields, New York State Department of Environmental Conservation, New York State Department of Health, May 2009.
  http://www.dec.ny.gov/docs/materials_minerals_pdf/crumbrubfr.pdf

  This study focused on three areas: release of chemicals into surface and groundwater and into air, and elevated surface temperatures. Laboratory-based leaching studies suggested that crumb rubber may be used as an infill without significant impact on groundwater quality. Field sampling studies were not fully completed at the time of the report and, although they showed no impact on groundwater quality due to crumb rubber related compounds, it was noted that the finding should not be considered conclusive, due to the limited amount of data available. Ambient air sampling measured the chemicals and particulates in the air at two fields and did not raise concerns for health effects of players at those fields. It was noted that temperatures on the surfaces of synthetic fields was significantly higher than on natural grass, and those using the fields should take precautions to avoid heat-related illness. The report did acknowledge that testing done under different conditions, using different methods or at different fields, could yield different results.

- A Review of The Potential Safety Risks from Synthetic Turf Fields Containing Crumb Rubber Infill, New York City Department of Heath and Mental Hygiene, Prepared by TRC Windsor, CT, May 2008.
  http://www.nyc.gov/html/doh/downloads/pdf/eode/turf_report_05-08.pdf

  "This comprehensive review of the available literature on the potential health effects of crumb rubber infill from synthetic turf fields has demonstrated that the major health concern from these fields is related to heat. Chemicals of Potential Concern (COPC) concentrations from the crumb rubber vary depending on the type of crumb rubber, the method of extraction used for analysis, and the media measured (crumb rubber, air, leachate). Eleven different risk assessments applied various available concentrations of COPCs and none identified an increased risk for human health effects as a result of ingestion, dermal or inhalation exposure to crumb rubber. However, additional air studies at synthetic turf fields as well as background air measurements would provide more representative data for potential exposures related to synthetic field use in NYC, particularly among younger field users."

State of New Jersey

- New Jersey Artificial Turf Investigation, State of New Jersey, Department of Health and Senior Services, Trenton, NJ. All associated documents available at: http://nj.gov/health/artificialturf/index.shtml, last modified August 11, 2008, 14:54:49.

  After a study of lead levels in twelve artificial turf fields in New Jersey, The New Jersey Department of Health and Senior Services concluded:

  "Agencies that have installed, are installing, or plan to install artificial turf fields should ask vendors to conduct appropriate testing to determine the levels of potential contaminants in components of the turf, including the turf fibers and in-fill materials. If a field is found to have high lead levels, field managers can consider limiting access to the field, especially for the most vulnerable population of children under 7 years of age. As a precaution, until further guidance is available, custodians of all turf fields, but especially turf fields with nylon fibers, can implement the following recommendations, in addition to testing their turf field:

  - *Dust suppression, in the form of watering down the field, can be conducted before and after the field is being utilized,*
  - *Encourage individuals who use the field to perform aggressive hand/body washing after playing on the field;*
  - *Clothes that were worn on the field should be taken off inside out and washed separately."*

  "The NJDHSS recognizes the growing public concerns about the safety of artificial turf fields, as well as the need for communities to provide for athletic and other recreational fields. Artificial turf fields are being installed in growing numbers around the country and in New Jersey. Health and safety concerns are being raised about these fields. These concerns are related to physical properties of the fields and potential chemical exposures from in-fill materials (especially crumb rubber from recycled tires) and the turf fibers.

  There is a need for a comprehensive and coordinated approach to evaluating the public health risks and benefits of artificial turf fields. Several assessments have been conducted by researchers around the country. Available evidence suggests that there are no acute health risks due to use of artificial turf fields, and risks due to chronic and repeated exposure are unlikely. However, important gaps and uncertainties in our knowledge of the nature and magnitude of potential exposures and health risks remain."

- Assessment of Environmental, Health, and Human Safety Concerns Related to the Synthetic Turf Surface at Maple Park in Ridgewood, NJ, Ridgewood Environmental Advisory Committee, Ridgewood, NJ, 2009.
  http://mods.ridgewoodnj.net/pdf/recreation/REACSyntheticTurfAssessmentFINAL2.pdf

  The Ridgewood Environmental Advisory Committee (REAC) is an independent volunteer committee, appointed by the village council, with experience and/interest in environmental issues. REAC appointed a subcommittee to investigate citizen concerns over the use of synthetic turf in a community park. REAC concluded that the synthetic surface at Maple Park did not pose any

significant environmental, health, or human safety threat. *"REAC's assessment focused only on concerns which may be applicable in Ridgewood and are specific to the synthetic 'infill' turf field design at Maple Park."*

Non-governmental Literature

- Natural Grass and Artificial Turf: Separating Myths and Facts, Turf Grass Research Center, East Dundee, IL. http://www.turfgrasssod.org/images/documents/033120095256858.pdf

  This document is a brochure prepared by the Turf Grass Research Center supporting the use of natural grass fields.

- Review of the Human Health and Ecological Safety of Exposure to Recycled Tire Rubber found at Playgrounds and Synthetic Turf Fields, July 17, 2008. Prepared for the Rubber Manufacturers Association, Washington, D.C, by ChemRisk, Inc. Pittsburg, PA.
  http://www.rma.org/newsroom/release.cfm?ID=252

  A report by an environmental firm on the human health and ecological risks from ground rubber in playgrounds and sports fields, and based on a review of studies from advocates and opponents to the use of crumb rubber. This report concludes no adverse human health or ecological health effects are likely to result from these reuses of tire materials. The report, however, acknowledges that while these conclusions are supported by existing studies or screening risk assessments, additional research would be useful.

- Review of the Impacts of Crumb Rubber in Artificial Turf Applications, Rachel Simon, University of California, Berkley, Laboratory for Sustainability and Manufacturing, College of Engineering, February, 2010. Prepared for The Corporation for Manufacturing Excellence (MANEX).
  http://www.4entech.com/Crumb%20Rubber%20Study_Feb_2010.pdf

  This report explores the various aspects of crumb rubber and addresses some of the claims made by various researchers. This report concludes that crumb rubber and artificial turf have many traits that make it a beneficial choice for athletic surfaces.

  > *"Generally safe application - Extensive research has pointed to the conclusion that these fields result in little, if any, exposure to toxic substances. A review of existing literature points to the relative safety of crumb rubber fill playground and athletic field surfaces. Generally, these surfaces, though containing numerous elements potentially toxic to humans, do not provide the opportunity in ordinary circumstances for exposure at levels that are actually dangerous. Numerous studies have been carried out on this material and have addressed numerous different aspects of the issue. For the most part, the studies have vindicated defenders of crumb rubber, identifying it as a safe, cost-effective, and responsible use for tire rubber."*

- Artificial Turf, Exposures to Ground-Up Rubber Tires, Athletic Fields, Playgrounds, Garden Mulch, David R. Brown, Environmental and Human Health, Inc., New Haven, Ct., 2007. http://www.ehhi.org/reports/turf/turf_report07.pdf

The summary and conclusions of the study are as follows:

"The Connecticut Agricultural Experiment Station study conclusively demonstrates that the tire crumbs and tire mulch release chemical compounds into the air and groundwater. Thus, tire crumbs constitute a chemical exposure for humans and the environment.

It is clear that the recycled rubber crumbs are not inert, nor is a high-temperature or severe solvent extraction needed to release metals, volatile organic compounds, or semi-volatile organic compounds. The release of airborne chemicals and dust is well established by the current information. The Connecticut Agricultural Experiment Station research conclusively demonstrates that release can occur under ambient conditions experienced in the summer in Connecticut.

Those published health assessments that indicate de minimis risk should not be applied to the synthetic turf paradigm and may not be appropriate for playgrounds with open layers of recycled tire crumbs.

Health endpoints of concern are numerous, including acute irritation of the lungs, skin, and eyes, and chronic irritation of the lung, skin, and eyes. Knowledge is somewhat limited about the effects of semi-volatile chemicals on the kidney, endocrine system, nervous system, cardio vascular system, immune system, developmental effects and the potential to induce cancers.

There are still data gaps that need to be filled in and additional studies are warranted.

It is prudent to conclude that there will be human exposures to chemicals released during the use of synthetic turf fields.

The excess amount of zinc in the rubber tire mulch makes it unacceptable to be used in gardens."

Finding: Parks and MCPS believe that reliance should be placed on the various government studies referenced above that have looked at the human health issues associated with artificial turf fields (and crumb rubber infill in particular) and have not found levels of concern that warrant avoidance of the construction of new artificial turf fields with crumb rubber infill.

Additional Reports Identified in Public Comments Received

References to a number of additional studies regarding potential health concerns related to exposure of participants to the artificial turf carpet and/or crumb rubber infill material were submitted to the Working Group, both during the development of the draft report as well as during the public comment period. The draft report focused on studies specific to artificial turf, especially with regard to government-sponsored studies. For the final report, a listing of the additional references received (along with direct quotes from the studies in cases where the studies were accessible) is included below. Some of these studies focused on artificial turf directly, while others involved the study of artificial turf ingredients in other settings that artificial turf opponents contend are relevant to the artificial turf issue.

Since DHHS does not believe it has sufficient expertise to assess the various studies, Parks and MCPS believe that reliance should be placed on the various governmental studies, many of which include a review of other studies available.

Report on Synthetic Turf Use in City Parks (San Diego Cost Parks and Recreation Review), May 2011. http://www.sandiego.gov/park-and-recreation/pdf/parkdesign/11syntheticturfuseguidelinesreport.pdf

"While the City has not conducted independent health or environmental analysis or tests of synthetic turf systems, there is a significant body of research conducted by other governmental agencies, universities and independent laboratories from which to draw. This information was reviewed in the drafting the proposed guidelines. Most current research on newer generations of synthetic turf concludes there is little to no health or environmental risks associated with synthetic turf. It is important for the City to continue to review research and monitor the use of synthetic turf in order to identify future risks to public health or the environment."

Centers for Disease Control Health Warning. http://emergency.cdc.gov/HAN/han00275.asp

"As determined by NJDHSS, limited sampling of additional athletic fields in New Jersey and commercial products indicates that artificial turf made of nylon or nylon/polyethylene blend fibers contain levels of lead that pose a potential public health concern. Tests of artificial turf fields made with only polyethylene fibers showed that these fields contained very low levels of lead."

Note: The fields used in Montgomery County are made from polyethylene, not nylon.

REDUCING ENVIRONMENTAL CANCER RISK What We Can Do Now"- President's Cancer Commission 2009. http://deainfo.nci.nih.gov/advisory/pcp/annualReports/pcp08-09rpt/PCP_Report_08-09_508.pdf

"Many millions of workers are exposed on the job to toxic and potentially carcinogenic or endocrine-disrupting chemicals, metals, fibers, combustion by-products, and other substances. Their exposures tend to be at considerably higher levels than those typically experienced by the general population."

Association of Black Carbon with Cognition among Children in a Prospective Birth Cohort Study, Am. J. Epidemiol. (2008) 167 (3): 280-286. HARVARD SCHOOL OF PUBLIC HEALTH. http://aje.oxfordjournals.org/content/167/3/280.full

Note: The above report studied carbon black as a marker for traffic particles (i.e., air pollution) from vehicle emissions (not from tires).

"While studies show that ultrafine and fine particles can be translocated from the lungs to the central nervous system, the possible neurodegenerative effect of air pollution remains largely unexplored. The authors examined the relation between black carbon, a marker for traffic particles, and cognition among 202 Boston, Massachusetts, children...In summary, this is the first study to have found a consistent relation between exposure to black carbon and reduced neurocognitive functioning across a number of domains in urban, community-dwelling schoolaged children. More studies are needed to explore the potentially neurotoxic effects of particulate matter, both to determine the possible impact on cognitive development among children and cognitive decline across the lifecycle and to determine the potential contribution of air pollutants to the development and exacerbation of neurodegenerative diseases (i.e., Parkinson's disease, Alzheimer's disease)."

Note: Another quote from the Discussion Section of the above study:

"There are several potential mechanisms that could be contributing to the associations found in this study. First, since black carbon comes almost entirely from traffic, these particles are surrogates for all traffic particles, and other components of traffic particles may play a role."

Final Report: Comparison of the Carcinogenicity of Diesel Exhaust and Carbon Black in Rat Lungs, EPA Grant Number: R828112C068I.
http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/2339/report/F

EPA Report Summary:

"The results of this carefully conducted study demonstrate that prolonged exposure to diesel engine exhaust and carbon black particles produces nearly identical carcinogenic and noncarcinogenic effects in this strain of rats. No significant differences were noted between the two exposure materials in the resulting incidence, number, or types of lung tumors. These results may be considered surprising because, compared with diesel soot, the carbon black particles were relatively free of mutagenic organic compounds. Both exposures caused injury to lung tissue, including inflammation, cell proliferation, and fibrosis. These lesions progressed in number and size as the dose of particles increased. At both exposure concentrations, diesel soot and carbon black accumulated in the rat lungs and, after three months of exposure, normal particle clearance mechanisms were impaired."

Note: Further in the report:

"However, it is clear that the tumors are associated with an impairment of the process by which inhaled material is cleared from the lungs; the impaired clearance process leads to a progressive accumulation of particles and damage to the surrounding tissues. This response appears to be dependent upon the species; for example, results from other studies have shown that hamsters do not develop lung tumors after exposure to high concentrations of particles, and the limited data available for mice are equivocal.

More information is needed about the mechanisms by which inhaled diesel exhaust and other particles cause lung tumors in rats before the results of the rat bioassay are used to predict lung cancer risk in humans. For example, we need to know if the same mechanism that produces lung cancer in rats also operates in humans, and if the sequence of events that leads to pulmonary tumors developing in rats after exposure to high concentrations of particles also occurs in humans exposed to much lower concentrations of particles, as in ambient settings. Dr. Mauderly's findings do not support extrapolating the rat carcinogenicity data to humans on the basis of the amount of organic material deposited in the lungs. However, uncertainties are associated also with extrapolating the data from rats to humans on the basis of the particle concentration or the lung burden of particles. Furthermore, the outcome of prolonged exposure to low levels of particles or particle-bound carcinogens, under conditions in which the lungs do not have a proliferative response to particles is unknown."

Annual Ambient Black Carbon Associated with Shorter Telomeres in Elderly Men: Veterans Affairs Normative Aging Study, Environ Health Perspectives 118:1564-1570. http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.0901831

Note: In the above Report:

> *"Background: Telomere length reflects biological age and is inversely associated with risk of cardiovascular disease (CVD). Ambient air pollution is associated with CVD, but its effect on telomere length is unknown.*
>
> *Objective: We investigated whether ambient black carbon (BC), a marker for traffic-related particles, is associated with telomere length in the Normative Aging Study (NAS).*
>
> *Conclusions: Telomere attrition, linked to biological aging, may be associated with long-term exposures to airborne particles, particularly those rich in carbon black, which are primarily related to automobile traffic."*

Study Says Carbon Nanotubes as Dangerous as Asbestos: New research shows that long, needle-thin carbon nanotubes [now added to tires to increase strength] could lead to lung cancer, By Larry Greenemeier, Tuesday, May 20, 2008. http://www.scientificamerican.com/article.cfm?id=carbon-nanotube-danger

> *"Inhaling carbon nanotubes could be as harmful as breathing in asbestos, and its use should be regulated lest it lead to the same cancer and breathing problems that prompted a ban on the use of asbestos as insulation in buildings, according a study in Nature Nanotechnology. During the study, led by the Queen's Medical Research Institute at the University of Edinburgh/MRC Center for Inflammation Research (CIR) in Scotland, scientists observed that long, thin carbon nanotubes look and behave like asbestos fibers, which have been shown to cause mesothelioma , a deadly cancer of the membrane lining the body's internal organs (in particular the lungs) that can take 30 to 40 years to appear following exposure. ... The researchers reached their conclusions after they exposed lab mice to needle-thin nanotubes: The inside lining of the animals' body cavities became inflamed and formed lesions."*

In the same article:

> *"Carbon nanotubes are generally made from sheets of graphite no thicker than an atom—about a nanometer, or one billionth of a meter wide—and formed into cylinders, with the diameter varying from a few nanometers up to tens of nanometers. (They can be hundreds or even thousands of nanometers long.)"*

Note: Graphite is elemental carbon, not carbon black, which is formed by the incomplete combustion of hydrocarbons or other carbon containing materials.

> *"The Edinburgh CIR study, which will also appear in the June issue of Nature Nanotechnology, was very specific, looking only at nanotubes that emulated fiber behavior and their potential to cause a*

certain type of cancer; other types of nanotubes could affect the body differently—for better or worse, researchers say."

Evaluating and Regulating Lead in Synthetic Turf. Environmental Health Perspectives (EHP) 118(10): Oct 2010 Van Ulirsch G, Gleason K, Gerstenberger S, Moffett DB, Pulliam G, et al. http://ehp03.niehs.nih.gov/article/fetchArticle.action;jsessionid=329B79696CEF833977FD20963FAB63BF?articleURI=info%3Adoi%2F10.1289%2Fehp.1002239

The above report states:

"On 18 June 2008, the Centers for Disease Control and Prevention (CDC) issued a Health Alert, recommending testing of fields that are made from nylon or nylon-blend fibers and have fibers that are abraded, faded, or broken, or contain visible dust."

The report concludes:

"To date, no study has linked turf exposures to elevated childhood blood lead levels. However, physicians should be aware of synthetic turf as one potential source of exposure for young children, especially given its use in residential, child care, or other play environments. Health officials investigating elevated blood lead in children should also be aware of synthetic turf as a potential source of lead exposure."

Note: Parks has tested the field fiber at the Montgomery Blair High School Field. The test results indicated no detectable level of lead. The fields used in Montgomery County are made of Polyethylene, not nylon.

Toxic Potential of Materials at the Nanolevel, Science 3 February 2006: Vol. 311. no. 5761, pp. 622 – 627, Andre Nel,1,2* Tian Xia,1 Lutz Mädler,3 Ning Li1. http://www.sciencemag.org/cgi/content/full/311/5761/622?ijkey=2eB0nrqZwskKs&keyt

The report abstract states:

"Nanomaterials are engineered structures with at least one dimension of 100 nanometers or less. These materials are increasingly being used for commercial purposes such as fillers, opacifiers, catalysts, semiconductors, cosmetics, microelectronics, and drug carriers. Materials in this size range may approach the length scale at which some specific physical or chemical interactions with their environment can occur. As a result, their properties differ substantially from those bulk materials of the same composition, allowing them to perform exceptional feats of conductivity, reactivity, and optical sensitivity. Possible undesirable results of these capabilities are harmful interactions with biological systems and the environment, with the potential to generate toxicity. The establishment of principles and test procedures to ensure safe manufacture and use of nanomaterials in the marketplace is urgently required and achievable."

Note: It is not clear if the nanotubes discussed are made from carbon black or from pure carbon.

The Staff Work Group could not determine the connection between carbon nanotubes discussed in this abstract and the crumb rubber used in artificial turf fields.

VI. Artificial Turf Heat Concerns

Background

One characteristic of artificial turf fields that has been well documented is the higher field temperatures on artificial turf fields as compared to natural grass fields under similar weather conditions. These conditions may vary depending on the color and other specifications of the artificial turf carpet and the type of the infill material used.[9]

A New York State Department of Health review (August 2008) of artificial turf (http://www.health.state.ny.us/environmental/outdoors/synthetic_turf/crumb-rubber_infilled/fact_sheet.htm) provides a good summary of findings regarding the heat effect of artificial turf utilizing crumb rubber infill:

> *"Synthetic turf fields absorb heat, resulting in surface temperatures that are much higher than the temperatures of the surrounding air. In June 2002 at Brigham Young University (BYU) in Utah, the average surface temperature on a synthetic turf field was reported to be 117°F while the average surface temperatures on natural turf and asphalt were 78°F and 110°F, respectively. A maximum surface temperature of 200°F on the BYU synthetic turf field was reported. A turf grass specialist at the University of Missouri reported measuring an air temperature of 138°F at "head-level" height on the university's artificial turf field on a sunny 98°F day. The surface temperature of the field was reported to be 178°F. A study conducted at Penn State University measured surface temperatures on experimental plots of nine different types of infilled turf. Temperature measurements were made on three occasions. The average air temperatures reported were 79°, 78°, and 85°F. The corresponding average surface temperatures reported for the synthetic turf plots are 120°, 130° and 146°F."*

Another study (Milone & MacBroom, 2008) also found elevated temperature levels on artificial turf fields in Connecticut:
http://www.miloneandmacbroom.com/Libraries/Documents/Evalutation_of_the_Environmental_Effects_of_Synthetic_Turf_Athletic.sflb.ashx.

The report summary regarding heat is reproduced below:

> *"The results of the temperature measurements obtained from the fields studied in Connecticut indicate that solar heating of the materials used in the construction of synthetic turf playing surfaces does occur and is most pronounced in the polyethylene and polypropylene fibers used to replicate natural grass. Maximum temperatures of approximately 156° F were noted when the fields were exposed to direct sunlight for a prolonged period of time. Rapid cooling of the fibers was noted if the sunlight was interrupted or filtered by clouds. Significant cooling was also noted if water was applied to the synthetic fibers in quantities as low as one ounce per square foot. The elevated temperatures noted for the fibers generally resulted in an air temperature increase of less than five degrees even during periods of calm to low winds.*

[9] Most of the material reviewed by the work group involves artificial turf with crumb rubber infill. For a discussion of alternatives to crumb rubber infill, please see the Section on Alternative Infill Products in this report.

The rise in temperature of the synthetic fibers was significantly greater than the rise in temperature noted for the crumb rubber. Although a maximum temperature of 156° F was noted for the fibers, a maximum temperature of only 101° F, or approximately 16 degrees greater than the observed ambient air temperature, was noted for the crumb rubber."

On Friday, September 24, 2010, at the Maryland SoccerPlex in Boyds, during its tour of both natural grass and artificial turf fields on the site, the Staff Work Group asked the Maryland SoccerPlex staff to measure temperatures on one of its artificial turf fields. Note: All of the SoccerPlex artificial turf fields utilize a crumb rubber infill. Here are the results:

- Air temperature at 2:30pm was 95.6 degrees
- Turf radiant temperature was 142 degrees
- Turf surface temperature was 103 degrees
- Asphalt radiant temperature was 121 degrees

Interestingly, the radiant temperature (taken about 6 inches above the surface) was greater than the turf surface. In fact, the turf surface was warm but not hot to the touch. However, while on the field, there was a noticeable "warm air" feeling not noticed immediately off the field.

Finding: Artificial turf fields with a crumb rubber infill (both the surface and the air several feet above the surface) can get very hot during peak hot weather conditions.

The Staff Work Group sought out any evidence that there was a higher level of incidence of heat-related medical issues with these fields than with natural grass fields. Once again, the New York Health Department study is instructive here:

"NYSDOH is unaware of any studies that have examined the role of synthetic turf in contributing to heat stress or that have compared the occurrence of heat stress among athletes playing on natural turf and synthetic turf."

Options for Addressing the Heat Issue

Average daily high temperatures in the Washington, DC area exceed 80 degrees 109 days per year and exceed 85 degrees 71 days per year (Source: TheWeatherChannel.com). While no days have average high temperatures over 90 degrees, it is not unusual for the area to experience 90 degree days. 2010 had a particularly high number of days (67) in which the daily high temperature exceeded 90 degrees (Source: Accuweather.com). Therefore, dealing with heat issues related to outdoor activities is an important issue for MCPS and Parks.[10]

The Staff Work Group identified two options for dealing with the temperature issue in artificial turf fields with crumb rubber infill:

[10] It should be noted, however, that MCPS, Parks, and Community Use of Public Facilities (CUPF) have not had any participants or permittees report any major heat issues associated with the use of their artificial turf fields.

- **Water the field regularly during high temperature periods:** This is a quick but only temporary way to reduce the field temperature. This strategy also requires irrigation equipment and staff to be present during these times. The New York Department of Health review of the BYU study notes:

  "Water can be applied to synthetic turf to reduce the surface temperatures on warm days. A study at BYU found that watering synthetic turf lowered the surface temperature from 174°F to 85°F, but the temperature rose to 120°F in five minutes and to 164°F in twenty minutes. A study conducted by Penn State University on experimental synthetic turf plots examined the effect of watering synthetic turf on surface temperature. Measurements were made on three occasions. For one monitoring period, surface temperatures ranging from about 130° to 160°F were lowered initially to about 75°F, but increased within 30 minutes to temperatures ranging from about 90° to 120°F, where they remained fairly stable for the three-hour monitoring period."

  Finding: Irrigation of artificial turf fields to reduce field temperatures does not appear warranted, given its limited effect and additional costs.

- **Restrict use of artificial turf fields during peak high temperature periods**: This approach is often taken by field owners who have staff on-site to make these day to day decisions on a case-by-case basis. The Staff Work Group was unable to find examples of entities utilizing specific requirements (such as an ambient temperature limit or actual field temperature) which would mandate field closure.[11]

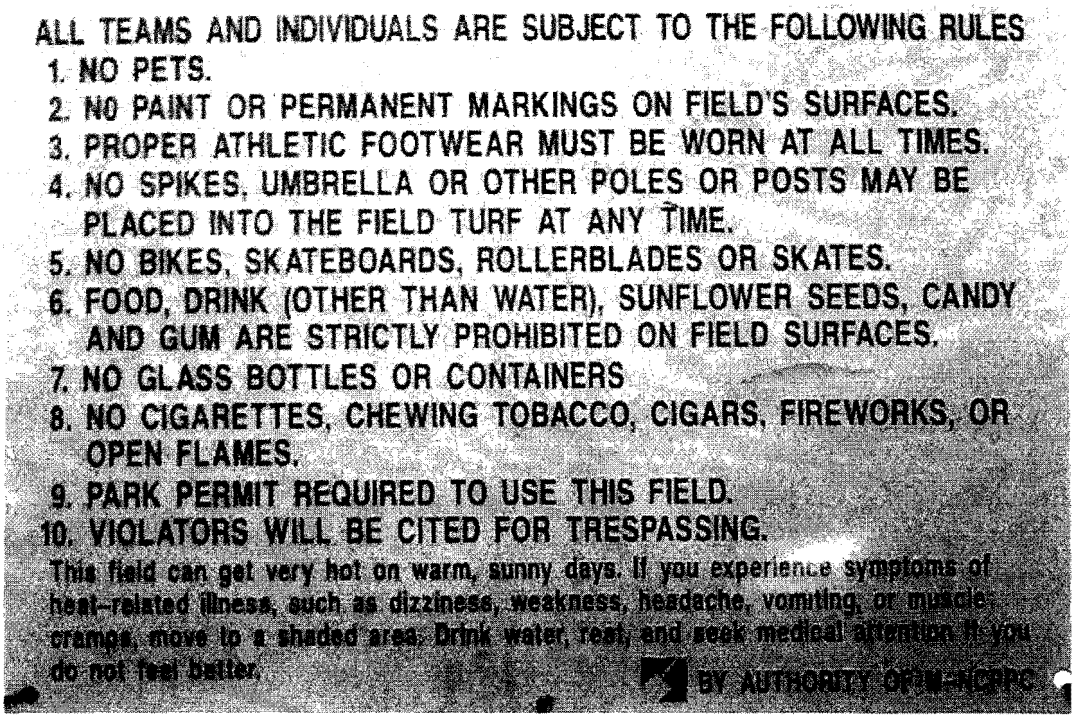
  The Maryland SoccerPlex (which has 3 artificial turf fields and 17 natural grass fields) moves games from its artificial turf fields to natural grass fields on extreme temperature days. During the record heat experienced in 2010, events from the artificial fields were moved to natural grass 13 different days.

  M-NCPPC Parks, which typically does not have staff on site at its artificial turf fields, includes the following language in its permit for the use of the Montgomery Blair High School turf field to emphasize with permittees the need to safely use the fields on hot days:

  "This field can get very hot on warm sunny days. If you experience symptoms of heat- related illness such as dizziness, weakness, headache, vomiting, or muscle cramps, move to a shaded area. Drink water, rest, and seek medical attention if you do not feel better. In extreme temperatures, please cease all activities and get off the artificial turf field."

  Similar language is posted on signs near the field.

[11] Taking actual readings on artificial turf fields (on the carpet itself and/or up to several feet above the carpet) can be done on a case-by-case basis. However, implementing a firm cutoff temperature would require monitoring and enforcement by the field permitter and may be arbitrary, given that other factors affect heat-related health risks, such as humidity and cloud cover that can change throughout the day.



Montgomery County Public Schools and Community of Use of Public Facilities (CUPF) also follow an "advisory" approach for its permittees. At this time, they do not include permit language or signage to specifically address the heat issue.

MCPS provides a "High School Athletics Handbook" to its schools (excerpt attached in Appendix E) with weather-related guidelines, including guidelines related to heat and air quality. For example, practices and games are cancelled under certain conditions, no matter the field.

Staff Work Group Recommendations:

- It is evident that surface and ambient temperatures on artificial turf fields can get quite hot. The Staff Work Group believes MCPS should include the artificial turf heat issue in its "High School Athletics Handbook" in order to address circumstances where these fields are being used and/or supervised by MCPS directly during peak heat conditions (for instance, for summer and early fall team practices and physical education classes).

  This guidance should provide for an assessment of field conditions on a case-by-case basis by the athletic staff at the school (considering ambient and field temperature readings).

- The Staff Work Group believes common permit language and advisory signage for all artificial turf fields managed by MCPS, Parks, and Community Use of Public Facilities (CUPF) should be utilized.

- Regarding specific permit language, signage, and guidance provided for users of artificial turf fields, the Staff Work Group suggests that CUPF conduct a process, which would include community user groups of artificial turf fields, to develop guidelines for use of the fields in hot weather.

VII. Environmental Impacts

One of the key issues which the T&E Committee requested that the Staff Work Group review is the environmental impacts of artificial turf and how these impacts compare to natural grass fields. Montgomery County Department of Environmental Protection (DEP) Staff participated in the Staff Work Group meetings and was asked by MCPS and Parks staff to review relevant studies, to consider whether the County should set up a water monitoring program for its own artificial turf fields, and to generally provide any recommendations DEP has with regard to the potential construction of future artificial turf fields. Staff from DEP assisted the Staff Work Group but also noted that DEP's participation would be limited, due to dedication of resources to support the implementation of the County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer Systems (MS4) permit.

DEP had previously provided to Council Staff a summary of its research with regard to the environmental impacts of artificial turf and some pros and cons vis-à-vis natural grass. This information was included in a June 29, 2010 Council Staff packet to the Council's Transportation, Infrastructure, Energy and Environment (T&E) Committee (later discussed at a July 1 Committee meeting). The information provided by DEP is included (in total) in Appendix F. The full Committee packet is available at: http://www.montgomerycountymd.gov/content/council/pdf/agenda/cm/2010/100701/20100701_TE1.pdf.

Water Quality Impacts

Stormwater Management

In considering the possible water quality impacts of natural grass and artificial turf, stormwater management requirements are an important consideration. These requirements are intended to provide both quantity (channel protection) and quality control.

Natural grass fields are considered pervious surfaces by the County's Department of Permitting Services (DPS) for purposes of stormwater management requirements. Prior to the new stormwater management standards (adopted by the State in May 2009, with an effective date of May 4, 2010) DPS required treatment of the first ¼ inch of runoff for newly established natural grass fields. This is typically achieved by building a crown in the center of the field and directing runoff into drainage areas along the edge of the field into grass swales or other types of stormwater management structures.

The new stormwater management standards (adopted in June 2010) require the use of best management practices to replicate the runoff characteristics of "woods in good condition". These practices involve the establishment of a target rainfall for each individual site, using the physical characteristics of the soils on the site along with what is being proposed for land cover. The target rainfall is then used to establish the volume of runoff required to be "managed". This may require different solutions, depending on specific site conditions.

Artificial turf is considered impervious for stormwater management purposes and is therefore treated similarly to pervious pavement. Based on the new stormwater management standards noted above, for a new artificial turf field, an additional depth of gravel under the artificial turf field is typically added to meet statewide infiltration design standards. This approach is similar to what was done for the Richard

Montgomery and Montgomery Blair high school artificial turf fields. The additional gravel depth provides a reservoir of space to slow the drainage of the stormwater (quantity control). The drainage of the stormwater into the soil below the gravel base provides the quality treatment. Conversely, the Walter Johnson and SoccerPlex fields have underdrains that direct flows to adjacent stormwater management structures for quality treatment via biofilters and/or sand filters and then a controlled release from a storage facility (quantity control).

Montgomery County DEP Review of Studies

The DEP staff looked at a number of studies focusing on water quality issues, especially with regard to the potential leaching of materials from the artificial turf carpet and/or the infill material, and the impact this leaching may have on the quality of the receiving stream and the aquatic habitat in the stream.

The DEP findings were:

- *Some studies have concluded that used tire products and artificial turf fields are unlikely to generate pollutants at a level above water quality limits (Lim and Walker 2009, Moretto 2007, Vidair, Haas and Schlag 2007, Ledoux, 2007, Lim, 2010, Bristol and McDermott 2008, Chemrisk 2008, Hofstra 2008, and Johns and Goodlin, 2008). Studies generally have found that fields have the potential to release low levels of pollutants when first installed, but that levels drop off very quickly to background levels. Only four of the studies listed above directly sampled runoff from actual artificial turf fields (Bristol and McDermott, 2008, Hofstra, 2008, Lim and Walker, 2009 and Moretto, 2007.)*
- *Studies done in other settings indicate that used tire products clearly have the potential to release toxic substances (Brown, 2007, Denly, Rutkowski and Vetrano, 2008, USEPA, 2009). Polycyclic aromatic hydrocarbons, zinc, and other metals are the principal substances of concern produced by used tires, although many other substances have been identified in small concentrations. It is difficult to relate these results to actual environmental conditions. Many of the identified substances are in low concentrations and may not be released under field conditions. Little information exists on the impacts of many of these substances. Most of them have no relevant government regulatory standards. However, it is also possible that synergistic impacts could occur when these substances exist in combination.*
- *Some studies have found toxicity to aquatic organisms from tire leachate or relatively high concentrations of pollutants. For instance, Sheehan, et. al. (2006) found that leachate from tire shreds installed below the water table reduced survival of aquatic organisms. The design of artificial turf fields places the rubber above the water table. Lim and Walker (2009) found that crumb rubber produced an average zinc concentration of 1947.4 ug/L in a Synthetic Precipitation Leaching Procedure (SPLP) test. This is much higher than the Maryland freshwater criterion for aquatic life of 120 ug/L. Their SPLP results also found relatively high concentrations of many other substances. However, Lim and Walker (2009) characterize this test as an, "Aggressive laboratory testing method ... which may overestimate releases from the samples as compared to releases in the ambient setting." Less aggressive laboratory procedures found lower concentrations of pollutants.*
- *Some studies have identified rare instances of lead on older artificial turf fields (NJDHHS 2008, NYCDPR Undated). The U.S. Consumer Product Safety Commission (CPSC 2008) has tied the lead in*

these fields to pigments used in the carpeting material and recommended that lead not be used in the manufacture of new fields. STAFF WORK GROUP COMMENT: MCPS and Parks staff note that their existing three artificial turf fields consist of carpets made of polypropylene (not nylon, as was the case in older artificial turf fields where lead was identified). Parks staff had a carpet sample from the artificial turf field at Montgomery Blair High School tested, and no detectable level of lead was found.

Subsequent to the July 1, 2010 T&E Committee meeting, DEP staff reviewed results from an ongoing synthetic turf monitoring plan (see appendix G) being managed by the San Francisco Public Utilities Commission (SFWater). SFWater provided DEP with some sampling results (see appendix H). DEP staff summarized these results by noting:

"With regard to zinc, one of the primary constituents of concern, the total zinc level is above the Maryland Toxic Substances Criteria for Ambient Surface Waters (120 ug/l) standard. However, the dissolved level is not above the acute toxicity level. Because the standard is based on the biologically available or dissolved concentration, the samples are below toxic levels based on Maryland standards."

A Staff Work Group member has contacted SFWater staff to collect additional information regarding the cost and status of the study and whether a similar study could be established here. DEP staff noted that a well-designed and detailed study would take "considerable time and cost and could still leave questions unanswered." The DEP staff believes such a study "would cost at least $100,000 and could be three to four times more."

The DEP staff was asked to comment on a July, 2010 report released by the Connecticut Department of the Environment. DEP provided the following comments:

"The study generally supports prior results. It does indicate that zinc in runoff could be a concern although they conclude that SWM should be able to address it. The stormwater data is limited though and far from conclusive."

The DEP staff also was asked whether the construction of artificial turf fields would impact the County's compliance with its National Pollutant Discharge Elimination System (NPDES) permit. The DEP staff noted that the construction of artificial turf fields

"should not affect NPDES permit requirements nor should it affect TMDLs. It is considered impervious by DPS (Montgomery County Department of Permitting Services) but would be considered treated to the MEP (maximum extent practicable)."

Comparing the Environmental Impacts of Natural Grass and Artificial Turf Fields

With regard to directly comparing the environmental impacts of artificial turf fields versus natural grass fields, the Staff Work Group was unable to find any comprehensive studies that quantitatively addressed this issue. DEP staff previously provided a general summary (see Appendix F). In short, DEP notes that

"Artificial turf fields are made of synthetic materials that require energy and other inputs including petroleum. Natural grass fields are laid down as sod or seeded and grown in place. Both sod and

seed are produced using fertilizer, energy and other inputs. It is difficult to say which of these processes are preferable from an environmental standpoint."

Below is some additional information collected by the Staff Work Group.

Maintenance Practices

In comparing maintenance practices for natural and artificial turf fields, a major difference is that the artificial turf fields do not require pesticides, fertilizers, irrigation, or mowing. The artificial fields do require grooming and sweeping on a much less frequent basis than the mowing of natural grass fields. For a sample listing of maintenance assumptions for different types of fields, please see Appendix C. Appendix C was developed using the expertise of SoccerPlex staff that are familiar with maintaining natural (Bermuda and cool season grass) fields as well as artificial turf fields in Montgomery County.

Carbon Footprint

The Staff Work Group was able to find one study by the Athena Institute of Ontario Canada (2007) (http://www.athenasmi.org/projects/docs/UCC_project_ATHENA_technical_paper.pdf) that calculated the carbon footprint of artificial turf versus natural grass, at the request of the Upper Canada College (a K-12 school) in Toronto, Canada, which wanted its switch from a natural grass to artificial turf field to be carbon neutral. The study looked at the manufacture, transport, installation, maintenance, and disposal of an artificial turf field versus the costs to build and maintain a natural grass field, assuming a 10 year time horizon. The study then calculated the greenhouse gas emissions (ghgs) offset (over ten years) to be 72.6 metric tons (based on an estimated 55.6 metric ton impact for an artificial turf field and -16.9 metric tons for natural grass. Offsetting this impact (through carbon sequestration) over a ten year period would require planting 1861 trees.

This report was reviewed by San Francisco's Synthetic Playfields Task Force in 2008 (report available for download at: http://www.verdedesigninc.com/pdf/SyntheticPlayfieldsReportFinalDraft082108.pdf). The task force noted a number of potential factors not included in the report, but agreed that the construction of artificial turf fields should be targeted to maximize the benefits and minimize the impacts (including greenhouse gas emissions).

A February 2010 study, "Review of the Impacts of Rubber in Artificial Turf Applications", by Rachel Simon of the University of California, Berkeley (Prepared For: The Corporation for Manufacturing Excellence (Manex)) also reviewed the Athena Study. The complete report is available at:
http://www.fieldturf.com/images/downloads/UC_Berkeley_-_Review_of_the_Impacts_of_Crumb_Rubber_in_Artificial_Turf.pdf

In reviewing the Athena Study, the Staff Working Group identified some limiting factors in extrapolating the Athena findings. One factor is that the ghg emissions from the transportation of materials are site-specific (based on where the materials to be purchased were made and assuming the materials are transported to Toronto, Canada) and thus would have to be revised based on locating a field in Montgomery County. It is also not clear what type of natural grass field was assumed for the comparison (sand base or native soil) and whether the construction, maintenance, and carbon sequestration might be different for the different types of natural grass fields.

Another major element not included in the Athena study is the differences in the hours of use of artificial turf fields over natural grass fields identified earlier. The impacts of constructing and maintaining additional grass fields would need to be factored into the analysis if assuming equal hours of use under both options. This is an important consideration, since the construction of a natural grass field from unimproved land, and the ongoing maintenance of that field, would involve ghg emissions that may close much of the gap identified in the study.[12]

Also, as noted earlier in this report, the carbon impact of automobile trips for all off-campus sports team practices was quantified at approximately 43.3 tons of annual carbon emissions (433 tons over ten years, or about 20 metric tons of emissions per high school). Since MCPS is able to keep many practices on site at its high schools with artificial turf stadium fields, there is the potential for significant ghg emissions reductions from avoiding off-campus team practices. Fewer game cancellations (discussed earlier) on artificial turf fields also would result in reductions in vehicle miles traveled and thus provide for a reduction in ghg emissions as well.

Finding: The impacts of material transportation, construction, maintenance, and loss of carbon sequestration result in artificial turf fields adding ghgs to the atmosphere when compared to a natural grass field. However, taking into account other factors (such as increased usage at one field rather than constructing additional new fields, keeping MCPS team practices on site, and reduced game cancellations) may eliminate much, if not all, of this ghg impact.

Heat Island Effect

Given that artificial turf fields generate higher temperatures immediately above the carpet surface than do natural grass fields (as described in more detail in Section VI), there could be some impact on urban heat islands associated with artificial turf fields. However, the degree to which artificial turf fields might exacerbate the problem are unclear, given the relatively few acres of artificial turf already constructed or planned in Montgomery County (MCPS' artificial turf fields are about 100,000 square feet or 2.3 acres in size) compared to Montgomery County's total land mass (approximately 500 square miles or 320,000 acres). A report by the New York City Department of Health and Mental Hygiene (2008) notes:

> *"The contribution of synthetic turf to urban heat islands is presently unknown. However, due to the increased temperatures measured on these synthetic turf systems, they may contribute local increased ambient temperatures, but their contribution to the overall urban heat island effect is likely to be small."*

The Staff Work Group was unable to find studies documenting the specific impact of a single artificial turf field.

[12] For instance, assuming the emissions numbers in the study, each natural turf field involved generates about 13.4 tons of ghg emissions from maintenance activities over a ten year period. Since the new fields could presumably have been unimproved land, much less of a carbon sequestration benefit may be assumed.

Recycling and/or Disposal of Artificial Turf Fields

Currently, if an artificial turf carpet is hauled to the Montgomery County transfer station, the hauler pays a tipping fee ($56 per ton for closed top vehicles or $60 for open top vehicles which would likely be involved with this material). An artificial turf carpet for a 100,000 square foot field weighs approximately 40 tons. Therefore, total tip fee costs for carpet disposal would be about $2,400.

The heavy backing on the artificial turf carpet does not burn well and, therefore, DEP sorts this type of carpet with other "non-processible" waste, rather than sending it with the regular trash stream to the Resource Recovery Facility (RRF) for incineration. Non-processible waste is trucked by contract from the transfer station to a landfill in Brunswick, Virginia at a current cost of $45 per ton. This cost (incurred in the County's Solid Waste Disposal Fund) would be offset by tip fee revenue noted earlier.

If the infill material (crumb rubber and sand weighing approximately 460 tons for a FieldTurf artificial turf field) used with the artificial turf field is also taken to the transfer station, this material would be sent to the RRF for incineration. The same tipping fees noted above apply and would amount to approximately $27,600. However, the $45/ton contracted hauling cost is not incurred, since the material is not going to the out-of-county landfill.

According to FieldTurf Tarkett, the crumb rubber and sand is reusable on a new artificial turf carpet and therefore would not go through the above-noted disposal process. FieldTurf Tarkett estimates total disposal costs at approximately $30,000 for the carpet (including both hauling and disposal).

From an operational standpoint, given the relatively few fields in place in Montgomery County, DEP does not see the future disposal of artificial turf carpets as a major issue. Note: In February of this year, Montgomery County's Solid Waste Advisory Committee (SWAC) transmitted some recommended actions related to artificial turf disposal to the County Executive for review (see Appendix K).

The County's solid waste policies prioritize waste reduction, reuse, and recycling ahead of incineration and landfilling, DEP supports MCPS' recommended approach of requiring artificial turf installers (as part of the contract for the installation of a new field) to reuse and/or recycle any artificial turf field components from the field being replaced. Similarly, new fields that are installed should to the maximum extent possible use non-virgin materials and/or materials that are conducive to future reuse or recycling.

FieldTurf Tarkett estimates the recycling costs for its artificial turf carpet to be $75,000 ($0.75 per square foot for a 100,000 square foot field). This $75,000 cost has been added to the 20 year lifecycle cost analysis (see Appendix D) for each of the two carpet replacements assumed.

Recommendation: Parks and MCPS staff should include language in future contracts requiring the recycling of artificial turf fields by the field installer.

DEP Recommendations

The Staff Work Group asked DEP to provide its perspective on artificial turf, based on its review of the various studies (see Appendix F). DEP staff were asked whether MCPS and Parks should not build any

more artificial turf fields, pending further environmental study. To date, DEP has not taken a position on this question. DEP has also not provided specific recommendations regarding the construction and use of artificial turf, such as whether water quality should be monitored for existing fields, if specific stormwater management practices should be utilized, or whether particular alternative infill choices should be pursued.

However, DEP is working with Parks on a monitoring plan for the new Laytonia Park, which is planned to include two rectangular natural grass fields and one artificial turf field. The location is in the Rock Creek Special Protection Area (SPA) and therefore, as the property owner, Parks is required to conduct water quality monitoring on proposed Best Management Practices (BMPs) to assure that they are protecting water quality. M-NCPPC is working together with DEP and DPS to develop a monitoring plan that will evaluate the effects of the Laytonia artificial turf field on water quality. The details of that plan are still being developed and are not available for this report. The results of this monitoring effort can help determine whether further monitoring of other artificial turf sites may be warranted.

Recommendations from Other Environmental Departments

Since the Staff Work Group did not receive specific recommendations from the Montgomery County DEP, the group reviewed a number of studies that focused on environmental issues and which included recommendations by an Environmental Department. Of particular help were the following two studies.

Connecticut Department of Environmental Protection, July 2010

The full report is available at:
http://www.ct.gov/dep/cwp/view.asp?a=2690&Q=463624&depNav_GID=1511, along with reports from other Connecticut agencies looking at various issues of concern regarding artificial turf.

The Connecticut DEP study's conclusion is reprinted in full below:

> *"The DEP concludes that there is a potential risk to surface waters and aquatic organisms associated with whole effluent and zinc toxicity of stormwater runoff from artificial turf fields. Zinc concentrations in the stormwater may cause exceedences of the acute aquatic toxicity criteria for receiving surface waters, especially smaller watercourses. The DEP suggests that use of stormwater treatment measures, such as stormwater treatment wetlands, wet ponds, infiltration structures, compost filters, sand filters and biofiltration structures, may reduce the concentrations of zinc in the stormwater runoff from artificial turf fields to levels below the acute aquatic toxicity criteria. Individual artificial turf field owners may want to evaluate the stormwater drainage systems at the fields and the hydrologic and water quality characteristics of any receiving waters to determine the appropriateness of a stormwater treatment measure.*
>
> *This study did not identify any significant risks to groundwater protection criteria in the stormwater runoff from artificial turf fields. It is important to note, that the DEP study did not directly collect and analyze groundwater at these artificial turf fields. Consequently, this conclusion regarding consistency with groundwater protection criteria is an extrapolation of the stormwater results collected and the evaluation of data presented in recent studies, such as Nillson et al (2008) and Lim et al (2009). To make a final conclusion regarding the overall risk from exposure to groundwater*

affected by stormwater runoff from artificial turf fields, further sampling and analysis of groundwater at the artificial turf fields would be required."

San Francisco Department of the Environment (SFE) (as part of a Synthetic Playfields Task Force Report completed in August 2008). (Full Task Force Report available at: http://www.superfill.net/dl010808/SFParks_Playfields_8.21.08.pdf.) The Task Force took a broad look at artificial turf issues and, more relevantly for this section, included SFE findings and recommendations.

Below are the SFE findings and recommendations as published in the Task Force report.

"The Precautionary Principle guides SFE's review and evaluation of the environmental impacts of city programs and initiatives.

It is important to note that the Precautionary Principle does ***not*** *advocate the avoidance of any and all potential environmental risks.*

The Principle does advocate for a public process in which the benefits of an action or technology are weighed against potential risks. The deliberation that occurs should explore and assess available alternatives for comparative risks, related financial and resource costs, and other immediate and long-term consequences.

In keeping with the basic tenets of Precautionary Principle, in January 2008 San Francisco Department of the Environment (SFE) issued a letter making the following key conclusions:

1. SFE recognizes potential environmental advantages and disadvantages from synthetic turf use.

2. SFE recognizes that human health risks are minimal from exposure to the crumb rubber infill used with synthetic turf products, according to the OEHHA study[13]. SFE recommended a precautionary approach to assessing these risks due to the lack of established reference doses for some ingredients.

3. SFE is concerned that there is currently no system available to recycle used synthetic turf, even though most of the products are composed of polyethylene, an easily recyclable plastic.

4. SFE recommends that RPD specify the use of recycled content materials in the manufacturing of artificial turf.

5. SFE recognizes the potential for aquatic toxicity from synthetic turf leachate, but also notes that leachate concentrations will not approach levels of concern in normal installations above water table.

FOOTNOTE FROM SF TASK FORCE REPORT: [13] In January 2007 the California Office of Environmental Health Hazard Assessment (OEHHA) published three studies for the California Integrated Waste Management Board (CIWMB) that evaluated rubberized matting used in playgrounds. The CIWMB needed to gain a better understanding of the potential health risks to children using outdoor playground and track surfaces made of recycled waste tires. In addition to an evaluation of toxicity, OEHHA also tested the playground surfaces for their ability to attenuate fall-related impacts and the potential of the rubberized surfaces to impact the local environment. CIWMB manages a grant program to promote markets for recycled-content products derived from waste tires in California. The OEHHA study found no evidence that rubberized matting used in playgrounds, a material similar in composition to synthetic turf infill, would cause danger or harm to human health or the environment.

6. There are several other potential health-related issues related to synthetic turf that are outside the scope of their review, including differences in sports injuries on synthetic turf vs. natural turf, and the potential for spreading methicillin-resistant Staphylococcus aureus (MRSA) among players.

San Francisco Department of the Environment Recommendations:

1. Create transparent selection criteria for determining which playing fields will have synthetic turf installed. These criteria should include the selection of sites that are not prone to flooding.

2. Confine installations of synthetic turf to the sites where its other benefits are maximized.

3. Due to the need for information regarding potentially toxic constituents, require full ingredients disclosure from manufacturers.

4. If hand-to-mouth exposure by children can be reasonably expected, post signs reminding parents to wash childrens' hands after play.

5. Due to concerns over end-of-life disposal, require that synthetic turf vendors guarantee take back of the product at end of life, and provide documentation that the product is recycled.

6. Pursuant to the ordinance regarding the use of recycled content materials in Public Works construction, SFE recommends that post-consumer recycled content materials be specified in the manufacturing of all components comprising artificial turf.

7. Do not permit the use of disinfectants on synthetic turf areas without full review by the Department of Public Health.

8. Obtain comments from the San Francisco Public Utilities Commission on both the potential water conservation benefits and the leaching concerns associated with synthetic turf products.

9. Obtain comments from the DPH Environmental Health Section on the human health risks discussed above."

Finding: While both the Connecticut and San Francisco environmental departments identified potential environmental impacts, neither study determined that these impacts were of sufficient concern to warrant a moratorium on the construction of artificial turf fields with crumb rubber infill. Instead, both departments recommend specific practices to reduce or mitigate these impacts.

NOTE: A Staff Work Group member contacted Dr. Chris Geiger of the San Francisco Department of the Environment (SFE) to find out what was happening in San Francisco now (since the Task Force report came out nearly 18 months ago). Dr. Geiger was a participant on the Synthetic Playfields Task Force and is still actively involved with the issue as SFE's Integrated Pest Management (IPM) and Green Purchasing Program Manager. He noted that the City of San Francisco (through the "City Fields Foundation") is in the process of building a number of artificial turf fields (with crumb rubber infill) in the city. Dr. Geiger noted that results from the ongoing SFWater study, mentioned earlier, found no issues of concern. An October 2010 OEHHS study on health impacts also found no issues of concern.

Dr. Geiger and Mr. Dan Mauer have assisted in the development of field specifications (see Appendix L for full specification) that include a number of provisions to address environmental and health concerns

and generally reduce the environmental footprint of the product. A summary of these provisions is provided in a memo from Dan Mauer to the San Francisco Recreation and Parks Commission (RPD) (see Appendix M).

Recommendation: Parks and MCPS staff should explore incorporating some of the environmental testing requirements identified in the City of San Francisco artificial turf specification into future specifications for artificial turf fields constructed for Parks and MCPS.

VIII. Alternative Infill Products

The artificial turf industry is expanding rapidly. Turf companies and infill manufacturers are attempting to respond to concerns with Styrene-Butadiene-Rubber (SBR) infill materials and are developing new alternatives. While a number of government studies discussed earlier have not found significant health and environmental concerns with the use of SBR in the latest technology crumb rubber fields, there continues to be active exploration of alternative infill materials that do not contain the hazardous substances found in SBR.

All artificial turf fields are systems built using similar components—an underground drainage system with a compacted gravel base, a polypropylene fiber carpet, and an infill product used in combination with sand to hold the carpet fibers upright and to cushion the surface to mimic the characteristics of natural grass. Different manufacturers vary the carpet fibers and infill materials to carve out a niche for their product. The artificial turf industry is operating in a young, expanding market, with companies emerging and failing with regularity. In an attempt to capitalize on the concerns generated around crumb rubber infills, a number of companies are bringing to market alternative infill materials aimed at addressing the heat issue and the uncertainty of chemicals contained in and released from crumb rubber.

There are basically five types of infill materials, in addition to sand, on the market—SBR Crumb Rubber, TPEs (Thermoplastic Elastomers), EPDM (Ethylene Propylene Diene Monomer) Rubber, Organic Infill materials, and Acrylic Coated Sand. Many manufacturers have entered the artificial turf infill market to respond to rapidly expanding demand for artificial turf fields, and some have marketed off-the-shelf materials developed for other applications. However, the artificial turf market is growing more sophisticated, with extensive research going into carpet fiber development and infill safety and durability. A high quality artificial turf field requires high quality carpet fiber and infill materials. In a highly competitive and maturing market, it is easy to understand why the failure of older artificial turf fields is reported and used as justification for use of one product over another. Each infill product on the market has advantages and disadvantages. It will take time for products to emerge that will have a proven record for durability and environmental friendliness.

Types of Infill

In order to develop a sense of the level of satisfaction with installations of artificial turf across the country, a Staff Work Group member contacted suppliers, installers, universities, and school districts to discuss their experiences with different combinations of turf infills. Based on those discussions, below is a brief description of each of the five different types of infill materials on the market, with some advantages and disadvantages of each and a listing of some recent installations.

SBR Crumb Rubber (Cryogenic and Ambient)—The vast majority of turf installations currently use SBR. Reports from agencies, including the Consumer Product Safety Commission and the U.S. Environmental Protection Agency acknowledge the presence of hazardous chemicals in crumb rubber, but find no evidence that the chemicals are released in harmful amounts or would be injurious to the health of athletes using the fields. Some manufacturers have not taken care in their manufacturing quality control, leading to a poor quality product. Poor quality control can cause problems applying the product,

problems with durability, and problems with not allowing the water to percolate - causing poor drainage. As noted earlier, cryogenic crumb rubber has been studied by a number of state and city agencies and has not been found to be detrimental to the environment or to athletes who use the fields. There is an added benefit to recycling thousands of tons of old tires that otherwise would end up in landfills. In Montgomery County, Richard Montgomery High School (2008), Montgomery Blair High School (2009), Walter Johnson High School (2010), and Fairland Regional Park (2010) all have crumb rubber infill. The manufacturer (FieldTurf) has provided letters indicating that at the end of the useful lives of the fields, the carpet and infill materials will be 100 percent recycled.

Thermoplastic Elastomers (TPEs)—There are many TPEs on the market. The advantage of TPEs is that they are made from virgin materials and some contain no lead, zinc, or other toxic materials. They also are cooler to play on. The drawbacks are that TPEs are very expensive to fabricate and are subject to wide manufacturing variations. Some TPE fields get hard over time. The problem with the generic name TPE is that it is a broad term. Many companies will use certain fillers that can be detrimental to the health of the player and the environment. Some TPEs can contain heavy metals. Others do not have crush resistance, flexibility, and softness. Some TPEs may not have UV stabilizers. The shape of the material will have an impact on the playability and safety. One particular product, Futrfill™ by Target Industries, shows promise as being free of heavy metals and toxins and is specified by the City of New York School Construction Authority (NYCSCA). NYCSCA installed one field in the fall of 2010, with two pending for 2011. The product should be recyclable for use as infill in a replacement field.

EPDM Rubber—(Ethylene Propylene Diene Monomer) is a virgin material that is durable, non-toxic, and environmentally friendly. It can be manufactured in a wide variety of colors and creates a surface that strongly resembles a natural grass playing surface. Given the ability to vary its color, the EPDM will not get as hot as an SBR field. EPDM has been used primarily in Europe, but has recently had problems with two major firms replacing a large number of fields, due to a reaction between the EPDM and the carpet fiber that causes a breakdown in the fiber. Brigham Young University installed an intramural field with EPDM infill in 2009. The field is light grey in color to reduce reflective heat. The EPDM material is recyclable.

Organic Infill Materials—Organics are new to the market, and they are not yet widely available. The advantage of organic infill materials is that they are non-toxic and environmentally friendly. Some are made from cork and coconut fibers (corkonut), while others are made of walnut shells. All are treated with an antimicrobial application to prevent deterioration of the infill. The drawback is that they have no track record for durability. Concerns include potential breakdown of the organic material, insects, and compaction of the material over time. The material is recyclable at the end of its lifecycle into other products, but could not be reused for infill for a new artificial turf field. In 2010, the city of Piedmont, California in the San Francisco bay area installed a GeoTurf™ (corkonut) organic infill artificial turf field, manufactured by Limonta, at an elementary school.

Acrylic Coated Silica Sand—There are now probably four to six companies in North America that produce this product. The advantage to acrylic coatings is that they are known materials, and most do not contain heavy metals and toxins. They will stay approximately 20 degrees cooler than crumb rubber fields. Acrylic material is hard and must be combined with a softer filler material. Some of the problems

with coated silica sands from some manufacturers are: a) the coating disperses in water; b) sand particles gel together; c) poor size distribution of sand; and d) poor quality silica sand before the material is coated resulting in the coating not adhering properly to the sand particles and breaking down over time. In 2009, the Los Angeles Unified School District (LAUSD) installed a FlexSand Action™ infill material at its Helen Bernstein High School. They are pleased with its performance.

Finding: Because the artificial turf industry is changing rapidly to meet the needs of its customers, decisions made on new companies and products should be well-researched to make sure that the money spent on artificial turf systems is based on sound lifecycle cost information.

Finding: Many owners, installers, and suppliers of artificial turf fields believe that crumb rubber is the best infill product on the market because it has been field tested and proven for performance, is readily available, utilizes recycled material, and is cost-effective over a number of years. Alternative infill materials are being marketed primarily to compete with crumb rubber, based on the negative perceptions attributed to SBR. While some of the alternative infills may show promise in terms of durability and performance over time, Parks and MCPS staff believe it is too early to invest in an unproven product until a greater track record is established for many of these materials.

Recommendation: Parks and MCPS believe that County agencies should continue to monitor the success or failure of alternative infills before considering a change from SBR infill material.

NOTE: Parks will consider installing and evaluating an alternative infill product if it installs artificial turf at the old Wheaton Ice Rink, due the relatively small size of the surface compared to an outdoor field. Parks will only specify an alternative infill if it can determine that the alternative has high potential to deliver equivalent performance to SBR at a reasonable cost without raising equivalent health and environmental concerns.

IX. Discussion of Public Comments to the Draft Report

The Draft Report of *A Review of Benefits and Issues Associated with Natural and Artificial Turf Rectangular Stadium Fields* was submitted for Public Comment on April 13, 2011. Public comments were received through June 7, 2011, and all of these responses have been included in Appendix N.

There were a total of 494 responses submitted regarding the Draft Report. Of the 494 responses, 460 (93%) were submitted in support of artificial surface stadium fields, and 34 (7%) were either not in support or otherwise expressed concerns. The purpose of this section of the report is to summarize the responses that were submitted, provide clarifications, and address specific concerns that may not have been included in the Draft Report. Adjustments made to the original draft report are noted.

Comments in Support

Among the 494 responses in support of artificial support, several were submitted by individuals representing larger groups, including Community Use of Public Facilities (CUPF); Montgomery County Public Secondary Schools Athletic Association (MCPSSAA – comprised of the 25 MCPS high school principals); MCPS Athletic Directors' Association; MCPS Boys' Soccer Association; MCPS Girls' Soccer Association; MCPS Girls' Lacrosse Association; Gaithersburg High School Band Parent Association; Gaithersburg High School Booster Club; and Rockville Youth Lacrosse Club.

Frequent comments submitted in support of artificial turf included: an enhanced level of safety (i.e., better field conditions as compared to natural grass fields); improved equity (more opportunities for individuals and teams to use high quality fields); financial benefits (reduced maintenance costs, higher revenue generation); and environmental benefits (reduced water, pesticides, and fertilizer usage). Also, fewer cancellations and optimal field conditions, even under heavy use, were frequently mentioned by those who commented.

The Staff Work Group believes the benefits cited in these comments were explored in the Draft Report and, therefore, no additional discussion is provided in this section of the Final Report.

Concerns and/or Comments Not in Support

Among the 34 responses that were either not in support of artificial surface stadium fields or otherwise expressed concerns, several were from individuals who identified themselves as representing larger groups, primarily coalitions or environmental groups, including Safe, Healthy Playing Fields Coalition; Parents Coalition of Montgomery County; Montgomery County Civic Federation; Neighbors of the Northwest Branch; Stormwater Partners Network; and Friends of Sligo Creek. Eighteen persons included comments in their response. Some persons and groups responded more than once.

The concerns raised regarding artificial turf fell into the following categories:

- Concern 1 – Traditional Field Maintenance Strategies and "Best Practices"
- Concern 2 – Health and Safety
- Concern 3 – Potential Level of Use, Lifecycle Costs and Revenue, other Procurement Issues
- Concern 4 – Environmental

These categories are discussed in more detail below, presented in an issue/question - answer format. The Staff Work Group believes many of the specific concerns raised were addressed in the Draft Report. However, in some cases, the Staff Work Group agreed that edits to the report were needed or at least further clarification of what was already in the draft report would be helpful.

Concern 1: Questions on Why Inexpensive, Traditional Field Maintenance Strategies Cannot Be Used

Some comments questioned whether available field maintenance strategies had been sufficiently explored, and why traditional methods could not be used to maintain high-use, high-quality rectangular fields.

Why is maintaining MCPS fields, or school fields in particular, different from maintaining other fields?

The Staff Work Group asked Dr. William (Duke) Beattie, Director of Systemwide Athletics for Montgomery County Public Schools, to elaborate on the particular challenges of maintaining high school stadium fields. His response follows:

"It is important to understand that high school stadium fields, in particular, are unique from other outdoor athletic facilities and traditional maintenance strategies are insufficient to keep these fields in optimal playing condition. Techniques that are effective on many fields simply do not apply to fields that are subject to such intensive levels of use. This is true in the Washington-Metropolitan Area and throughout the nation. To summarize from pages 14-20 of the report, there are no methods available that can adequately and consistently address maintenance and playability issues associated with a field that simultaneously must accommodate 12 teams, including two football teams, who collectively play over 100 games a year, that are:

- *conducted in the prime growing seasons of fall and spring, and are*
- *played over a concentrated span of five months, and that*
- *involve mature young adults and a consistently high level of competition, with pressure to*
- *play the games even in rainy or adverse weather conditions."*

Why can't MCPS copy techniques used in other places?

Three specific facilities were frequently referenced among the concerns that were expressed. These three facilities – The Town of Branford, Connecticut Parks and Recreation; St. Mary's College (Maryland); and Churchill High School (Montgomery County) were each mentioned multiple times as model facilities and as evidence that alternative maintenance strategies are viable practices that should be considered, instead of building artificial turf fields. Page 15 of the report notes that Staff Work Group members contacted the Branford Parks and Recreation Department as well as St. Mary's College.

As mentioned in the Draft Report, high school teams in the town of Branford, Connecticut play on an artificial surface stadium field. This fact supports the points made earlier in this chapter by Dr. Beattie that high school field use (and in particular high school football) entails a very different set of maintenance demands than community field use.

St. Mary's College (Maryland) was also referenced in multiple responses as a model facility. However, as pointed out on page 15 in the Draft Report, the St. Mary's College stadium field hosts half as many

contests as a typical MCPS stadium field, and their athletic program does not include football. One cannot make a fair comparison between the St. Mary's stadium field and an MCPS stadium field. It is a much simpler task to maintain a stadium that includes only 150 hours of use per year and does not include football.

With regard to Churchill High School, the Staff Work Group again turned to Dr. Beattie of MCPS for additional information:

> *"Churchill High School maintains two high quality Bermuda surface fields. In this regard, Churchill High School is unique from most other MCPS schools because it is able to divide competitive contests over two high-quality surfaces (field hockey has its own dedicated, fenced, Bermuda surface facility). There is thus less wear and tear on the stadium field. Moreover, Churchill High School spends an average of $91,500 per year on field maintenance ($106,500 and $76,600, respectively, in FY 2010 and 2011), approximately three-times the amount of average MCPS field maintenance costs. While the Churchill model represents one way to provide high quality athletic fields, most high schools do not have the space to allow for two competitive game facilities, let alone the financial resources to have the facilities professionally maintained."*

The physical limitations of pursuing this model at most high schools, the high annual maintenance costs, and the fact that no community use is allowed on Churchill's fields (and thus no outside revenue to offset the increased costs) led the Staff Work Group to believe this approach is not a feasible alternative for most high schools.

It is important to note that, even assuming MCPS ultimately builds artificial turf fields at many of its high schools over the next 20 years, the vast majority of MCPS' owned ballfields will still be natural grass, and MCPS will need to continue to look at best practices in the industry for constructing and maintaining natural grass ballfields.

Concern 2: Health and Safety

Has the issue of heat been adequately addressed?

Excessive heat was a frequent concern expressed regarding artificial surface fields. This issue was addressed by the Staff Work Group on pages 37-40 of the Draft Report.

There is ample evidence that artificial surface fields can get very hot in the summer months when subject to direct sunlight. However, no public or private organizations have indicated that heat is an insurmountable issue. As noted in the report, the most viable approach to dealing with the heat issue is to avoid use of the fields during peak heat times.

The Staff Work Group recommends that heat-related policies be established by Community Use of Public Facilities (CUPF) to ensure consistent and safe use of artificial turf fields by permittees. The Staff Work Group also recommends that MCPS address this issue in the "MCPS High School Athletics Handbook."

What input did Health and Human Services provide?

There was direct participation of the County Health Officer, an epidemiologist and a representative of environmental health. These participants reviewed all the documents provided, as well as other studies, articles, and reports. As stated in the report, DHHS noted that it is not equipped with the necessary specialized expertise to conduct a health assessment of either the artificial or natural grass already in place or to determine what material to use in the future. DHHS can assist MCPS and Parks in ensuring that policies and procedures that maximize the level of safe and healthy use and exposure related to athletic field use are based on sound scientific and public health practices.

Regarding the meta-analysis suggested in the draft report. DHHS staff consulted with staff from the Maryland Department of Health and Mental Hygiene, who suggested that meta-analytic techniques could not necessarily be applied to this topic ,due to insufficient and inconclusive data on human exposures and health outcomes. Therefore, the meta-analysis recommendation has been removed. NOTE: The Maryland Department of Health and Mental Hygiene is not currently studying artificial turf, nor does it take a specific position on the issue.

Are there other health concerns that have not been identified or addressed?

References to a number of additional studies regarding potential health concerns related to exposure of participants to the artificial turf carpet and/or crumb rubber infill material were submitted to the Staff Work Group, both during the development of the draft report and during the public comment period. The draft report focused on studies specific to artificial turf, especially government sponsored studies. For the final report, a listing of the additional references received (along with direct quotes from the studies in cases where the studies were accessible) is included in the "Public/Human Health Concerns" section of the Final Report. Some of these studies focused on artificial turf and crumb rubber infill directly, while other studies looked at the ingredients in artificial turf and/or crumb rubber infill but in other settings (such as in roadways and factories).

Since DHHS does not believe it has sufficient expertise to assess the various studies, Parks and MCPS believe (as noted in the draft and final report finding of the Public/Human Health Concerns" section) that reliance should be placed primarily on governmental studies, many of which include an extensive review of other applicable public and private studies.

Concern 3 – Potential Level of Use, Lifecycle Costs and Revenue, and other Procurement Issues

There were a variety of concerns raised regarding the lifecycle costs, revenues, and hours of use and other assumptions in the Draft Report.

Why is there no comparison to current maintenance practices and costs at high school stadium fields?

Current practices are noted in the Staff Work Group report in various sections. The hours of use section notes current and potential hours of use for MCPS and Parks natural grass fields. The lifecycle cost analysis looks at cool season native soil fields as well as Bermuda Grass native soil fields (which are the two types of fields that MCPS and Parks have now).

However, MCPS' maintenance practices and dollars spent vary substantially from school to school, so this report's cost analysis has attempted to choose a reasonable average that makes sense, based on discussions with MCPS and Maryland SoccerPlex staff. It should be noted that, even at the high schools spending the most on field maintenance (Churchill High School spends an average of approximately $91,600 per year in field maintenance for its two Bermuda Grass native soil fields), field use is tightly controlled and no community use is allowed.

Maintenance at Parks fields also varies substantially, based on the needs of a particular field. However, according to Parks staff, no amount of maintenance can overcome overuse of fields, which many of Parks' fields are experiencing now.

For the cost of one artificial turf field, couldn't many natural grass fields be built and maintained for high-quality use over the long-term?

Some comments critical of artificial turf lifecycle cost analysis noted the substantially higher up-front cost for artificial turf fields over natural grass fields, and questioned if one could redirect these dollars to high-quality natural grass field construction and maintenance, instead of artificial turf fields.

The Staff Work Group's lifecycle cost analysis takes into account the higher up-front costs for artificial turf fields. The result of this analysis clearly notes that the costs for an artificial turf field over 20 years are higher than for natural grass fields. However, the Staff Work Group's lifecycle cost analysis recognizes that the substantially higher available hours of use from an artificial turf field as compared to a natural grass field should be taken into account in order to make a true apples-to-apples comparison of costs. The cost per hour of use is an important consideration. Also, with the increased hours of use available, revenue generation from new or increased community use also must be taken into account.

The lifecycle cost analysis considers both the increased hours of use and the potential increased revenue, and concludes that the net cost per hour of use is substantially lower for artificial turf fields than for natural grass fields in the case of MCPS stadium fields. For a Parks artificial turf field, the lifecycle cost conclusions are more mixed, since the hours of use are assumed to be less than at a high school stadium artificial turf field.

Apart from lifecycle cost considerations, a natural grass field is more subject to damage and to weather conditions than an artificial turf field. With regard to the practicality of redirecting more resources to field maintenance, the Staff Work Group again turned to Dr. Beattie to comment:

> *"First, installation of a new surface is not an easy process, and its success depends on many factors, including timing – timing in regard to what time of year the field is installed, and timing in regard to how long the field had to take hold before being subject to use. In this respect, it is impossible for a school to simply install a new surface every year – the field would have to be rested (no games) for at least one growing season. Accordingly, a field would need to remain unused for either the entire fall or the spring season, depending when it was installed."*

Is the replacement cycle for artificial turf overly optimistic, given the high use assumed at the fields?

The lifecycle cost section assumes an artificial turf field must be replaced after eight years (the warranty period). If anything, this may be an overly conservative assumption, as some percentage of fields should be expected to last longer than eight years. Over the 20 year period covered in the lifecycle analysis, two carpet replacements are assumed. The carpet replacement is assumed to cost about one-half the cost of a brand new field since the initial site work, stormwater management, and equipment costs are not incurred with a carpet replacement.

The Staff Work Group Report included a section on hours of use assumptions for artificial turf fields. The MCPS and Parks warranties allow for up to 3,000 hours of annual use. Actual use is estimated at 2,300 hours of use for MCPS' high school stadium fields and 1,000 hours of use for Parks fields, and 1,800 hours of use for the Maryland SoccerPlex. These usages are all well within the amounts allowed for in the warranties.

Are the maintenance costs for artificial turf indicated in the report understated?

As with natural grass fields, maintenance cost assumptions can vary from place to place, based on how a maintenance program is organized (centralized, decentralized, contracted out), the maintenance philosophy and practices pursued, local labor rates, and many other factors.

In "A Guide to Synthetic and Natural Turfgrass for Sportsfields Selection, Construction, and Maintenance Considerations by the Sportsturf Managers Association" (dated November 2008 and available at: http://www.stma.org/_files/_items/stma-mr-tab1-2172/docs/2nd%20edition.pdf), a range of $5,000 to $25,000 for artificial turf field maintenance is noted. A cost analysis prepared for the Candadaigua School District in New York assumes a $7,500 artificial turf annual maintenance cost. Summary available at:
http://www.canandaiguaschools.org/files/24258/athletic%20committee%20boe%2010%2021%2010.pdf

A cost analysis of an indoor artificial turf practice field prepared by the athletic turf manager at Michigan State (included in the public comments in Appendix N) comes up with an annual cost of $22,760.

However, as mentioned above, costs can vary substantially by site. The Michigan State analysis assumes a $5,000 per year cost to add crumb rubber infill. However, by comparison , the Maryland SoccerPlex fields did not have crumb rubber infill added until this year (their 4th year of operation). The Richard Montgomery field had crumb rubber infill added last fall (after two years of use), but that cost was borne by the contractor (FieldTurf Tarkett) within the context of the warranty and maintenance agreement. FieldTurf Tarkett does not recommend routine additions of crumb rubber infill to its fields unless insufficient amounts were added at the time of construction or later practices, such as snow plowing, are utilized, which can lead to a loss of crumb rubber on the field. The Staff Work Group's cost analysis took a middle approach and assumed that crumb rubber infill is added once during the life of the carpet (every 4 years). This is consistent with the experience at the Maryland SoccerPlex.

Painting costs of $1,000 per year are also assumed in the Michigan State example. However, MCPS' and the SoccerPlex fields have lines permanently stitched into the carpet and don't require any painting. Also, seam repairs (which are handled under a maintenance contract) are $1,200 more per year in the

Michigan State example than what is paid for at the Richard Montgomery field. There are a number of other costs/practices (such as disinfectant, irrigation, fabric softener, and others) which are included in the Michigan State numbers but which are not applicable to MCPS' or Parks' maintenance practices.

Similar comparative difficulties arise when looking at a cost analysis done by the City of San Diego Park and Recreation Department (also cited in the public comments and available at: http://www.sandiego.gov/park-and-recreation/pdf/parkdesign/11syntheticturfuseguidelinesreport.pdf). The construction costs, maintenance, usage, and other assumptions (for both artificial turf and natural grass) are far different than assumptions identified in other studies and actual experience in Montgomery County.

The Staff Work Group believes that the best assumptions to use for its lifecycle cost analysis are actual costs incurred by Parks and MCPS for its existing artificial turf fields. These costs (and the maintenance assumptions) were then discussed with Maryland SoccerPlex staff to ensure MCPS and Parks' practices were reasonable, given typical industry standards.

The Staff Work Group based the $10,000 per year artificial turf maintenance cost assumed in its lifecycle cost analysis on MCPS, Parks, and the Maryland SoccerPlex's maintenance practices. For example, at Richard Montgomery High School, the booster club is paying $6,800 per year for an annual maintenance and inspection contract for the school's artificial turf field. This contract covers repair work as needed during the year, plus quarterly inspections and maintenance as needed. The High School Athletic Directors are responsible for grooming and sweeping the AT fields on a regular basis and do this work during their regular workday. According to Dr. Beattie, an estimate of total hours of maintenance time required outside the contract is about 40 hours per year. An hourly rate of $25 per hour would result in an annual labor cost of $1,000, resulting in annual maintenance costs of $7,800 per year. A higher hourly rate or additional hours of work would increase the number. The Staff Work Group believes that the $10,000 number provides a sufficient cushion in case the hourly rate or hours required are higher than currently assumed.

Do the costs for artificial turf include disposal fees?

The Staff Work Group report includes a section on disposal issues and notes that disposal of the artificial turf field would be the responsibility of the contractor replacing the old artificial turf field, and that the contractor would be required to recycle the field (if practicable). Based on discussions with staff from the City of San Francisco Department of the Environment, there is no inherent reason why the carpet cannot be recycled and the crumb rubber and sand infill reused. The San Francisco turf specifications (included in Appendix L of the report) include a section requiring the contractor to provide a recycling plan for the field being installed.

What, if any, cost impact the disposal/recycling requirement would have on the purchase price of a new field is unknown. However, FieldTurf Tarkett estimates the disposal costs for a 100,000 square foot carpet to be approximately $30,000. The crumb rubber infill and sand is reusable in a new carpet.

FieldTurf Tarkett estimates the recycling costs for its artificial turf carpet to be $75,000 ($0.75 per square foot). For the Final Report, the $75,000 cost has been added to the lifecycle cost analysis, which would cover recycling or disposal costs if they are passed on to MCPS or Parks by the contractor.

Are the assumed revenues for artificial turf overstated in the lifecycle analysis?

The lifecycle cost analysis in the draft report assumed 1,000 hours of community use for an artificial turf field. The 1,000 hours charged at the non-profit/in-County CUPF rate of $125 per hour equates to $125,000 per year. The lifecycle cost analysis in the draft report assumed $100,000 in revenue per year (or 80% of this total) for both MCPS' and Parks artificial turf fields.

Based on actual FY11 community hours of use information for the artificial turf fields at Richard Montgomery, Walter Johnson, and Blair high schools collected subsequent to the draft report, combined with annualized revenue from the partnership agreements at Richard Montgomery and Walter Johnson high schools, the annual revenue estimates in the lifecycle cost analysis have been reduced from $100,000 to $80,000 per year. Actual revenue at any new fields will depend on whether a private sector partner is involved (and the negotiated cost per hour of use) and/or the actual community use hours booked at CUPF rates.

For a dedicated Parks artificial turf field, estimated hours of use and lifecycle costs are more difficult to predict. Full-year data is not available for the Fairland Park field (the only Parks artificial turf field that is not also an MCPS stadium field). As noted in the report, the Montgomery SoccerPlex is able to utilize its artificial turf fields 1,800 hours per year on a schedule of available hours that is similar to Parks' hours of use for its rectangular ballfields. For this lifecycle analysis, the same $80,000 revenue per year (as assumed for MCPS' artificial turf fields) is assumed.

For the final report, additional information has been included in Section III "Playability (Hours of Use)" and Section IV "Lifecycle Costs", based on the information described above. The lifecycle cost information has also been updated to account for the reduced annual revenue assumptions for the artificial turf fields.

As more artificial turf fields are built, won't the revenue generation for any one field will go down?

Over time, if more artificial turf fields are built, it is possible that community use at some artificial turf fields may decline. However, as noted in the report, both Parks and CUPF believe there is substantial pent-up demand for the use of high quality rectangular stadium fields because of the existing shortage of rectangular ballfields (see Page 14 of the Report). Since only one new Parks artificial turf field and three MCPS artificial turf field conversions are planned in the next six years, the Staff Work Group believes the community use assumptions are reasonable at this time. However, as noted earlier, the annual revenue assumptions for artificial turf fields have been reduced for the final report.

Wouldn't avoiding play during peak heat periods reduce the revenue assumed?

As mentioned earlier, the Staff Work Group recommends that heat-related policies be established by Community Use of Public Facilities (CUPF). The issue of closing fields during peak heat times is taken into account in the hours of use assumptions in the report. Most community use and MCPS use of its current

artificial surface fields occurs during times other than peak heat periods. As noted earlier, the annual revenue assumptions are based on actual community use hours experienced at the Richard Montgomery and Blair High School fields, which have had to take into account peak heat conditions (as well as other conditions such as heavy snow) which would preclude the use of the fields.

Why is there no assumption for costs related to vandalism or other damage at artificial turf fields?

Vandalism is a concern with any facility, government or private. To date, MCPS and Parks have not had a problem with vandalism or damage to their artificial turf fields. While vandalism is a possibility, the fields are gated and used by permit only, which minimizes opportunities for vandalism. Maryland SoccerPlex staff noted that it has not had any vandalism incidents at any of its fields (natural grass or artificial turf).

When schools install artificial surface fields, standard practice is to include a large piece of carpeting that is stored on the roof of the school. In this fashion, if a field is vandalized, the replacement carpeting will have "aged" a similar degree as the carpeting in the stadium.

Montgomery County Public Schools self-insures for issues such as vandalism. The inclusion of artificial turf fields into the inventory of facilities covered under this approach is not assumed by MCPS to significantly affect actuarial costs over time.

There also is no assumption of vandalism to a natural grass field or abuse to the field in wet weather or in drought conditions. There is arguably a greater likelihood of damage to a natural grass field in wet weather than there is of damage to an artificial turf field due to vandalism. It would be difficult to estimate the cost for either case in a lifecycle cost analysis.

Do Montgomery County Parks and MCPS have a no-bid exclusive deal with just one artificial turf supplier: FieldTurf Tarkett.

This report focuses on the benefits and issues associated with natural and artificial turf and not the procurement choices pursued by MCPS and M-NCPPC Parks.

MCPS belongs to a regional purchasing cooperative that bids the procurement of artificial turf fields. MCPS uses the regional cooperative's bid to contract for the artificial turf field. It is important to note that site preparation and stormwater management facilities are bid as part of a project's site work, which is bid separately from the purchase and installation of the artificial surface.

MCPS is satisfied with the price obtained and quality of the fields built at Richard Montgomery High School and Walter Johnson High School through its contract with FieldTurf Tarkett. M-NCPPC Parks reviewed a variety of potential vendors and chose to bid contracts to FieldTurf Tarkett approved vendors only. Parks staff are also satisfied with the price obtained and quality of the fields built at Montgomery Blair High School and Fairland Recreational Park.

There are a variety of processes one could choose for building an artificial turf field. Each process will have pluses and minuses. For instance, the Maryland SoccerPlex hired its own general contractor (rather than an artificial turf company) who has experience as a subcontractor for artificial turf companies. This contractor oversaw the purchase of the field materials and the construction of its 3 artificial turf fields.

Isn't FieldTurf Tarkett suing its supplier for providing them with defective materials?

Legal issues associated with one or more artificial turf companies are beyond the scope of the Staff Work Group's report. However, the Staff Work Group included a field specification from the City of San Francisco that both MCPS and Parks staff have indicated would be a useful document to ensure quality fields are built. It should also be noted that a comprehensive 8 year warranty is the industry standard for artificial turf fields (including the fields built for MCPS and Parks). This warranty provides significant protection for MCPS and Parks with regard to defective materials and substandard performance of the field.

With regard to the specific lawsuit referenced, the Staff Work Group received the following response from FieldTurf:

"The action asserts claims for, among other things, fraudulent inducement of contract, breach of contract and breach of warranty. FieldTurf alleges that Mattex Leisure Industries ("Mattex"), the predecessor to TenCate Middle East, employed a bait-and-switch scheme against FieldTurf, which was one of Mattex and later TenCate's largest and most loyal customers. Our belief is that once it secured a contract with FieldTurf, Mattex changed its fiber formula and the manufacturing process that it used to create the fiber and, unbeknownst to FieldTurf, began to supply FieldTurf with a fiber that did not meet contract specifications or perform as warranted. The complaint alleges that, once TenCate acquired Mattex, TenCate continued to supply FieldTurf with fiber that, in at least some instances, did not meet contract specifications or perform as warranted. The complaint further alleges that, because of Mattex and TenCate's misconduct, FieldTurf built more than 100 fields using defective fibers that are degrading prematurely.

To avoid any possible misunderstanding, here are the key facts on several important items:

- *While we have recently become aware of some turf fiber quality issues in a certain type, earlier generation field, it has not been a uniform issue in all FieldTurf fields that fit that type and our best approximation suggests these fields represent only 100 or 1.5% of our 7,000 fields.*
- *Some earlier generation monofilament fields located in higher UV environments fit the profile. Importantly, there are no health/safety concerns in connection with the field issues. The company has determined that the prematurely degrading fields were manufactured with the fiber that was supplied by Mattex and later TenCate.*
- *While we are seeking legal recourse against TenCate, FieldTurf is committed and well-placed to honor its warranties, remediate where applicable any customer issues to this end and continue to operate its business without interruption.*

The litigation also included claims arising from what FieldTurf believed to be TenCate's wrongful termination of its supply agreement with FieldTurf. On February 18, 2011, TenCate notified FieldTurf of its intention to terminate the supply agreement on March 2, 2011, due to purported breaches of the agreement by FieldTurf. TenCate further notified FieldTurf that it would not supply it with any fiber after the purported termination date.

What is most important is that this issue has absolutely nothing to do with the safety & performance of our fields. It has everything to do with a third party supplier that, in our view, simply did not live up to what they promised and committed to do...."

Does MCPS have to buy 3 fields within 3 years from FieldTurf in order to secure the price paid for the first two fields?

The Staff Work Group asked James Song, the Director of Facilities Management for MCPS, about this contention. He noted that *"There is NO commitment for MCPS to purchase 3 AT fields within a 3 year period. The cost is based on each individual project."*

Concern 4 – Environmental

A number of public comments expressed concern regarding the environmental impacts of artificial turf, especially with regard to water quality impacts, and argued that no additional fields should be built until water quality testing of the existing artificial turf fields is done.

The report includes a section on environmental concerns (Section VII) that discusses water quality and other issues regarding artificial turf and natural grass fields. With regard to water quality testing in particular, Section VII notes that DEP staff feel "that a well designed and detailed study would take 'considerable time and cost and could still leave questions unanswered.' The DEP staff believes such a study 'would cost at least $100,000 and could be three to four times more.'" This cost and effort is beyond the scope of this Staff Work Group.

The Staff Work Group looked at water quality studies done by other jurisdictions, such as the State of Connecticut and the City of San Francisco. Information regarding these studies is included in Section VII of the report.

Also, subsequent to the release of the draft report, DEP began working with Parks on a monitoring plan for the new Laytonia Park, which is planned to include two rectangular natural grass fields and one artificial turf field. The location is in the Rock Creek Special Protection Area (SPA) and therefore, as the property owner, Parks is required to conduct water quality monitoring on proposed Best Management Practices (BMPs) to assure that they are protecting water quality. M-NCPPC is working together with DEP and DPS to develop a monitoring plan that will evaluate the effects of the Laytonia artificial turf field on water quality. The details of that plan are still being developed and are not available for this report. The results of this monitoring effort can help determine whether further monitoring of other artificial turf sites may be warranted.

As a result, the following recommendation has been added in the Final Report "**Recommendation: Parks and DEP staff should collaborate on the development of a water quality testing regime at the future Laytonia Park.**"

Appendices

A. Summary of Artificial Turf Fields (ATF) Located at Maryland and Neighboring Public School Systems

B. Warranty for Montgomery Blair High School artificial turf field

C. Lifecycle Cost Maintenance Assumptions

D. Lifecycle Cost Analysis Detail and Assumptions

   1. MCPS high school stadium fields

   2. Montgomery County Parks fields

E. Excerpt from MCPS Athletic Handbook on Heat and Air Quality

F. Montgomery County Department of Environmental Protection attachment to the July 1, 2010 Montgomery County Transportation, Infrastructure, Energy and Environment Committee meeting packet

G. Results from an ongoing synthetic turf monitoring plan being managed by the San Francisco Public Utilities Commission (SFWater)

H. Sampling Results from SFWater

I. Letters from Montgomery County Citizens Advisory Boards

   1. Western Montgomery County CAB Letter to The Honorable Nancy Floreen, President, Montgomery County Council, September 30, 2010

   2. Mid-County CAB Letter to the Honorable Isiah Leggett, County Executive and Ms. Mary Bradford, Director, Montgomery County Parks, June 17, 2010

J. Resolution from the Montgomery County Stormwater Partners Network, undated

K. Solid Waste Advisory Committee (SWAC) – Annual Meeting with the County Executive, February 10, 2011

L. City of San Francisco Specification for Artificial Turf Fields

M. Memo from Dan Mauer, dated July 8, 2009, to the San Francisco Recreation and Parks Commission on provisions to reduce the environmental footprint of artificial turf fields

N. All Comments Received on the Draft Report During the Public Comment Period (April 13, 2011 through June 7, 2011)

Appendix B

Life Cycle Assessment of Artificial and Natural Turf Sports Fields – Executive Summary

Zürcher Hochschule
für Angewandte Wissenschaften

Life Sciences und
Facility Management

IUNR Institut für Umwelt und
Natürliche Ressourcen

Life Cycle Assessment of Artificial and Natural Turf Sports Fields – Executive Summary

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INTRODUCTION AND METHOD

Football is among the most popular sports globally. All that is needed for a football match is players, a ball and a sports field. However, the latter is not simply grass, but rather a precisely defined and constructed structure, which can be made of natural, hybrid or artificial turf. It is the aim of the city of Zurich to reduce both the primary energy consumption and the greenhouse gas emissions that are produced by each resident. In order to analyse and compare the environmental impact of different types of turf sports fields, Grün Stadt Zürich commissioned the Zurich University of Applied Sciences to carry out a Life Cycle Assessment (LCA) study.

In cooperation with the sports field experts who build and maintain the sports fields in the city of Zurich, primary data for the entire life cycle of the turf sports fields was collected. Based on this data, life cycle inventories were compiled for two sports fields using natural turf, two using artificial turf, and one using hybrid turf, covering all life cycle phases as summarised in Tab. S.1.

Tab. S.1 Overview of different types of natural and artificial turf sports fields under study

Type	Description
Natural turf, no drainage	Natural turf without drainage layer
Natural turf, drainage	Natural turf with drainage layer according to DIN
Hybrid turf, reinforced	Hybrid turf using natural turf reinforced with plastic fibres
Artificial turf, unfilled	Artificial turf without infill made of plastic or other granulate
Artificial turf, filled	Artificial turf filled with granulate made of primary plastics

The Life Cycle Inventory model includes the production and construction of the turf sports fields, as well as maintenance, renovation, dismantling and disposal. The LCA study does not include indirect environmental impacts caused by the users of the turf sports fields, such as during travel to and from the site or through the required sports clothing or nutrition. The data that was used for this study was derived from input data from the city of Zurich. The results, therefore, only have limited transferability to other geographical regions.

The functional unit of this study is defined as one hour of use of the respective artificial and natural sports field in the city of Zurich. Artificial turf fields can be used more intensively than natural turfs, which results in a higher number of annual usage hours. The consideration of different annual usage hours allows for a fair comparison of the different types of turf.

The study is largely based on the requirements of ISO 14040 / 14044 (ISO, 2006a; ISO, 2006b; ISO, 2017). The study was also subjected to a critical review in parallel with the study according to ISO 14040 / 14044 (ISO, 2006a; ISO, 2006b; ISO, 2017) by a committee of three independent experts:

This executive summary is derived from the full report from Itten et al. (2020). The full report on the study is available in German at https://doi.org/10.21256/zhaw-20774.

ENVIRONMENTAL IMPACT PER HOUR OF FOOTBALL

The LCA includes a selection of the indicators recommended by the Joint Research Council of the European Commission for the Organisational and Product Environmental Footprint (Fazio et al., 2018) shown in Fig. S.1. Based on the theoretical maximum hours of use, which differs according to the type of turf, the unfilled artificial turf sports field has the lowest environmental impact of all the indicators examined, except for greenhouse gas emissions and primary energy demand over the entire life cycle. For the other turf sports field types, the results differ, depending on the environmental impacts studied.

In the case of the natural turf sports fields, the construction and operation life cycle stages alone cause more than 80 % of the environmental impacts for all of the indicators analysed shown in Fig. S.1. During operation, the environmental impact of natural and hybrid turf is significantly higher compared to artificial turf, especially for eutrophication, since the production of the required mineral fertiliser is energy-intensive and the emissions that result from its application have eutrophying effects.

The environmental impacts of artificial turf sports fields are driven by the construction and renovation life cycle stages, which account for more than 65 % of the environmental impacts for all indicators shown in Fig. S.1. The renovation stage has higher impacts for artificial turf sports fields compared to natural turf sports fields, due to the additional material required to replace the artificial turf layer.

The filled artificial turf sports field has the highest environmental impacts per hour of use for greenhouse gas emissions, freshwater eutrophication, mineral resource use as well as total primary energy demand and non-renewable primary energy demand, mainly due to the required filling material. The replacement as well as the disposal of the filling material causes additional impacts for the filled artificial turf sports fields in the renovation and operation life cycle stages. Furthermore, the filled artificial turf sports field causes microplastic emissions due to the discharge of filling material. There is no established methodology to account for the environmental impacts caused by microplastic emissions recommended by the Joint Research Council of the European Commission for the Organisational and Product Environmental Footprint (Fazio et al., 2018). Therefore, the microplastic emissions are not represented in Fig. S.1. The environmental impacts of microplastic emissions are discussed in a separate chapter in the full report for the study in German (Itten et al., 2020).

Accordingly, an unfilled artificial turf sports field is always the preferable option with lower environmental impacts compared to a filled artificial turf sports field for all the indicators analysed in this study.

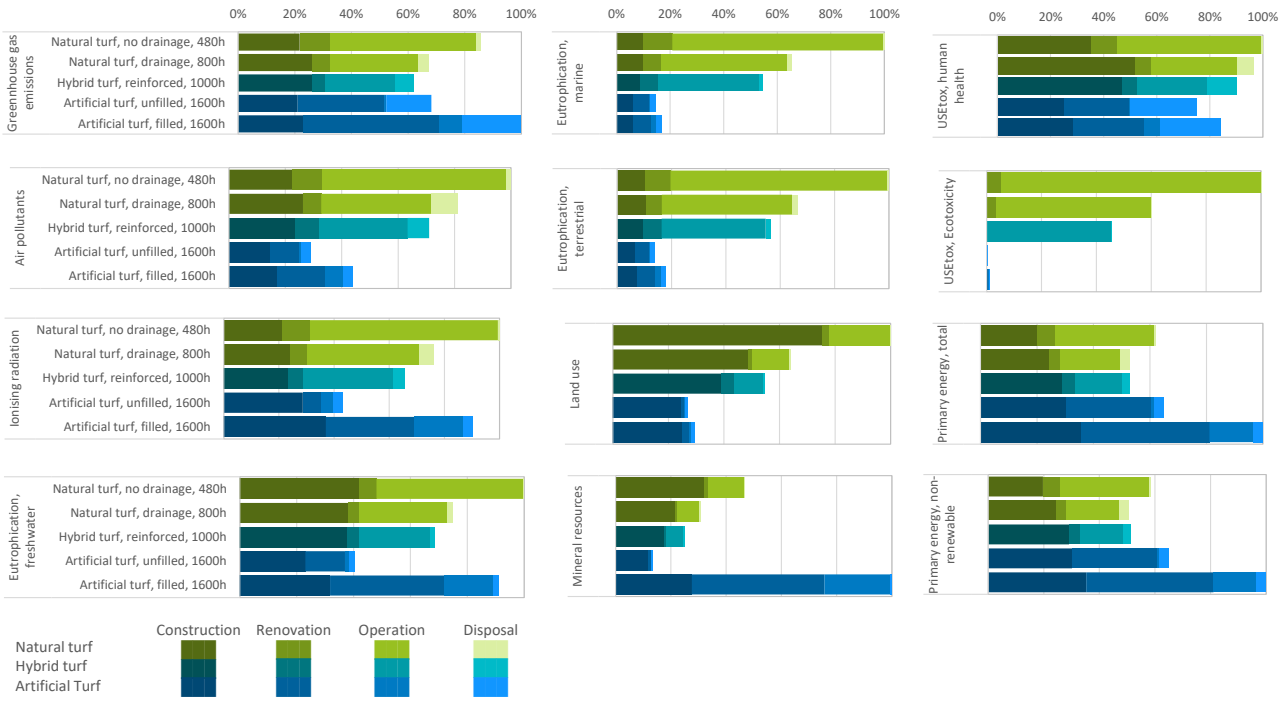

Fig. S.1: **Environmental impacts of the different turf sports fields per theoretical hour of use for the different midpoint categories according to the recommendations from Product Environmental Footprint by Fazio et al. (2018), greenhouse gas emissions by IPCC (2013), primary energy demand by Frischknecht et al. (2007), and human and eco-toxicity by USETox (Rosenbaum et al., 2011) divided into the contributions of construction, renovation, operation and disposal. The theoretical number of hours of use is 480 and 800 hours for natural turf without and with drainage layer construction, and 1,000 and 1,600 hours for hybrid and artificial turf sports fields, respectively.**

In addition to the midpoint indicators in Fig. S.1, the aggregated total environmental impacts according to the Ecological Scarcity Method according to Frischknecht et al. (2013) are shown in Fig. S.2. The comparison per hour of use considers the environmental impacts caused by the construction, operation and disposal of the sports fields as well as the annual usage hours. The results also show the differences between the theoretically possible and the actual annual usage hours accounted for in the city of Zurich.

The high result for hybrid turf in Fig. S.2 is subject to uncertainty, since for this type of turf usage data from only one hybrid turf sports field was available. The differences between natural turf and artificial turf are more robust. For both the theoretical and the effective annual usage hours, the unfilled artificial turf has the lowest environmental impact per hour of use.

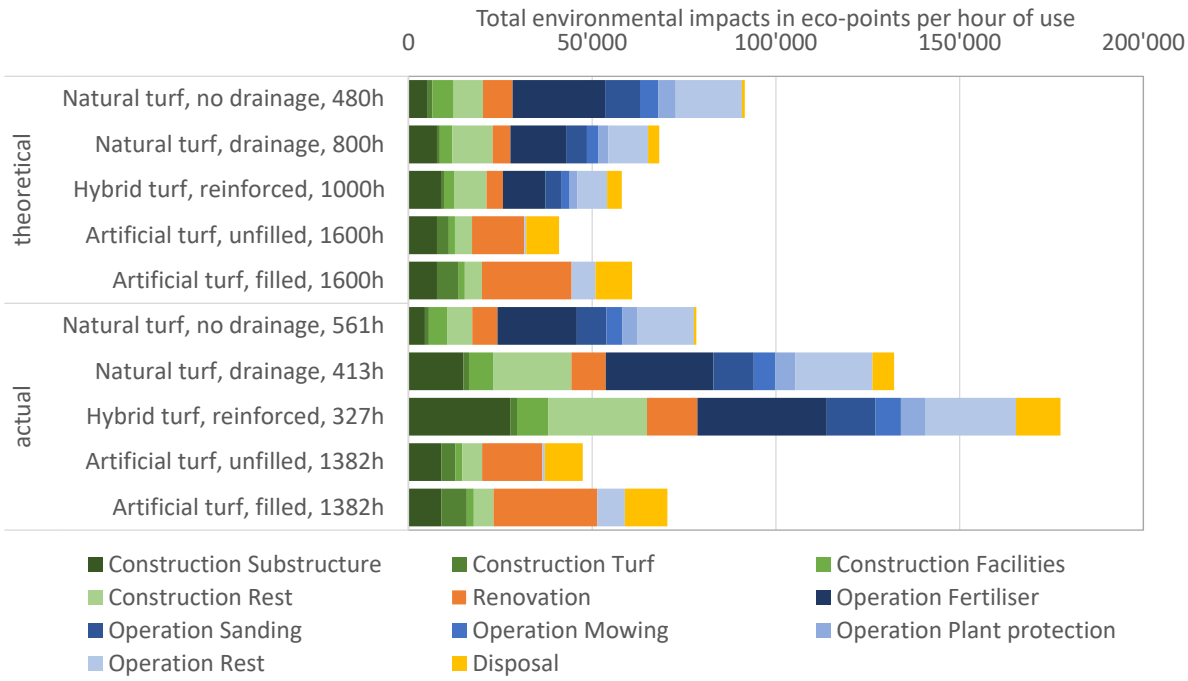

Fig. S.2: **Total environmental impacts of the different turf sports fields per theoretical and actual hour of use according to the ecological scarcity method (Frischknecht et al., 2013) divided into the 11 most important contributions from construction, renovation, operation and disposal.**

The annual usage hours have a major influence on the environmental impacts of sports turf, particularly because different types of turf for sports fields allow for different maximum annual usage hours. If the number of annual usage hours is identical, the natural turf without drainage causes the lowest total environmental impacts and the filled artificial turf causes the highest total environmental impacts according to the Ecological Scarcity Method 2013. However, since natural and hybrid turf allows for fewer hours of use, on average an artificial turf causes lower greenhouse gas emissions and a lower total environmental impacts per hour of use according to the Ecological Scarcity Method than a natural or hybrid turf. A natural turf with a drainage layer construction, which is played on for 800 hours per year, causes approximately the same amount of greenhouse gas emissions per hour of use as an unfilled artificial turf, which is played on for 1,600 hours. However, if an unfilled artificial turf is only used for 800 hours per year, it causes significantly more greenhouse gas emissions per hour of use than a natural grass turf with a drainage layer or a hybrid turf. Fig. S.3 shows the greenhouse gas emissions per hour of use for the different types of turf under study depending on the total annual usage hours.

The most important factor for the environmental impact is the annual usage hours. Artificial and hybrid turf can be played on for much longer per year than natural grass. At optimal capacity utilisation, artificial turf sports fields have significantly lower environmental impacts per hour of use.

However, the annual usage time not only depends on the turf type, but also on other factors like the existing infrastructure for lighting that allows for longer daily usage of the sports fields.

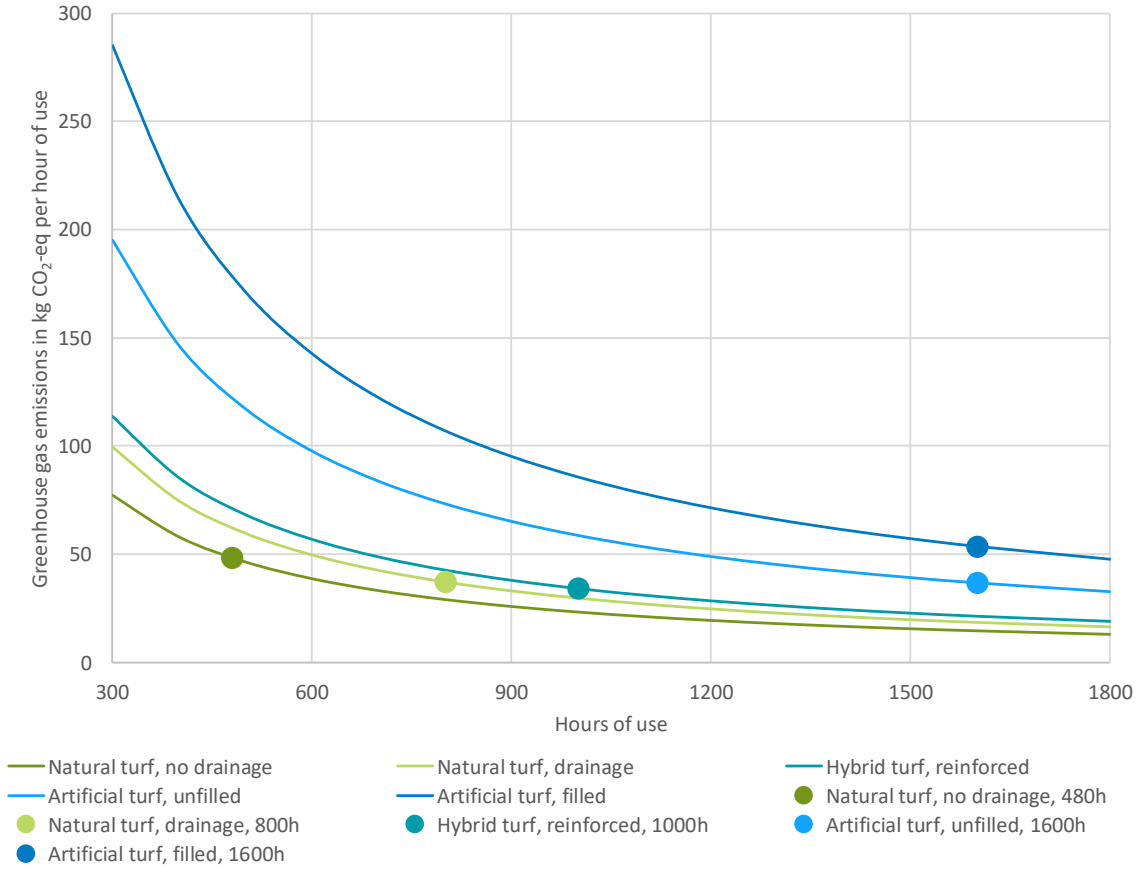

Fig. S.3: **Greenhouse gas emissions in kg CO2-eq according to IPCC (2013) per hour of use depending on the total hours of use per year visualised for the natural, hybrid and artificial turf sports fields under study; data points indicate the theoretical hours of use.**

REDUCTION POTENTIALS FOR THE FOOTPRINT OF FOOTBALL

The environmental impact of artificial and natural turf sports fields can be effectively reduced by optimising the annual usage hours of the existing fields. The optimisation of the annual usage hours also efficiently reduces the pressure for the construction of additional sports fields. In general, intensively used pitches have significantly lower environmental impacts per hour of use than extensively used pitches. The data on annual usage hours suggests that the use of the existing turf sports infrastructure in the city of Zurich is not fully optimised. Therefore, before new construction or conversions are carried out, the utilisation of existing sports fields should first be increased.

When planning new sports turf, the number of hours of use should be estimated as accurately as possible so that the optimum type of turf can be selected for the sports field. This means that for high intensity of use, artificial turf is more environmentally sustainable, and for less intensive use, a form of natural grass is. In general, the chosen sites should allow for the highest possible number of annual usage hours.

At present, almost all artificial turf is produced from primary plastic. Environmental impacts caused by the construction of artificial turf sports fields could be reduced by using recycled secondary plastics. However, the use of recycled secondary plastics may also have adverse effects which increase the environmental impact, e.g. due to the use of plastic granulate contaminated with heavy metals made from scrap tires as infill for filled artificial turf sports fields.

A customer, such as the city of Zurich, could and should encourage artificial turf producers to use recycled secondary plastics in cases where these will have a positive impact on the environment. It could also be investigated whether existing artificial turf could be renewed or recycled instead of disposing it in municipal solid waste incineration plants.

The choice of turf type is only relevant for new construction or replacement of sports turf. For existing sports turf, however, there are possibilities to optimise the environmental impacts caused by the maintenance of the existing sports fields. In the case of the investigated natural and hybrid turf sports fields, fertilisation causes a high share of greenhouse gas as well as eutrophying emissions. With a reduced use of mineral fertiliser, these environmental impacts can be reduced accordingly.

Although mowing sports turf only contributes just under 6% of the total environmental impact of natural grass turf in drainage layer construction, this amount could be significantly reduced by transitioning from conventional mowing with diesel engines to mowing robots powered by certified green electricity.

With these recommendations, the life cycle assessment study supports the environmental optimisation of the planning and management of artificial and natural turf sports fields.

REFERENCES

Fazio, S., Castellani, V., Sala, S., Schau, E., Zampori, L., & Diaconu, E. (2018). Supporting Information to the Characterisation Factors of Recommended EF Life Cycle Impact Assessment Method. Ispra, Italy: European Commission, Joint Research Centre, Institute for Environment and Sustainability.

Frischknecht, R., Büsser Knöpfel, S., Flury, K., Stucki, M., & Ahmadi, M. (2013). Swiss Eco-Factors 2013 According to the Ecological Scarcity Method. Methodological Fundamentals and Their Application in Switzerland (Umwelt-Wissen Nr. 1330) (p. 256). Berne: Federal Office for the Environment.

Frischknecht, R., Jungbluth, N., Althaus, H.-J., Doka, G., Dones, R., Heck, T., Hellweg, S., Hischier, R., Nemecek, T., Rebitzer, G., & Spielmann, M. (2007). Overview and Methodology. Dübendorf, CH: Swiss Centre for Life Cycle Inventories.

IPCC. (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

ISO. (2006a). Environmental Management - Life Cycle Assessment - Principles and Framework. ISO 14040:2006; Geneva: International Organization for Standardization (ISO).

ISO. (2006b). Environmental Management - Life Cycle Assessment - Requirements and Guidelines. ISO 14044:2006. Geneva: International Organization for Standardization (ISO).

ISO. (2017). Environmental Management - Life Cycle Assessment - Requirements and Guidelines. ISO 14044:2006/AMD 1:2017. Geneva: International Organization for Standardization (ISO).

Itten, R., Glauser, L., & Stucki, M. (2020). Ökobilanzierung von Rasensportfeldern : Natur-, Kunststoff- und Hybridrasen der Stadt Zürich im Vergleich. Wädenswil, Schweiz: ZHAW Institut für Umwelt und Natürliche Ressourcen.

Rosenbaum, R. K., Huijbregts, M. A. J., Henderson, A. D., Margni, M., McKone, T. E., van de Meent, D., Hauschild, M. Z., Shaked, S., Li, D. S., Gold, L. S., & Jolliet, O. (2011). USEtox - the UNEP-SETAC Toxicity Model: Recommended Characterisation Factors for Human Toxicity and Freshwater Ecotoxicity in Life Cycle Assessment. International Journal of Life Cycle Assessment, 16(8), 710–727.

Appendix C

Charlotte-Mecklenburg Study

The following information is from a study conducted by this consultant in the Charlotte-Mecklenburg, NC area:

The following are key observations from a maintenance cost comparison provided by Shaw Inc. of Artificial turf vs. Natural grass prepared for the project:

- The Artificial turf field had 1,030 projected reserved uses in a year, in comparison to 542 projected reserved uses for the natural grass field.
- The total projected yearly expense for the artificial turf field was $2,360, in comparison to $18,819 for the Natural grass field.
- Total projected yearly revenue for the artificial turf field was $66,950, in comparison to $21,680 for the natural grass field.
- Initial startup costs for the artificial turf field were $500,000, in comparison to $150,000 for the natural grass field.
- Projected expenditures for a 12-year cycle for the artificial turf field was $40,320, in comparison to $290,728 for the natural grass field.

Denver Study

The following information is from a study conducted by this consultant in the Denver, CO area:

- The City of Denver spent an average of $2,645 on labor for maintenance of each natural grass field, in comparison to an average of $1,763 on labor for maintenance of each artificial turf field.

The artificial turf field would provide many opportunities for revenue generation through rentals and hosting of tournaments and events.