MEMORANDUM

April 14, 2015

To: Matthew Finch
Design & Construction Manager
Edmonds School District

From: Elisabeth Black, CIH
EMB Consulting, LLC

Re: Literature Review for Health Risks Associated with Artificial Turf/Crumb Rubber
Proposed Synthetic Turf Installation
Former Woodway High School

At your request, I have reviewed 32 separate documents provided by the Edmonds School District (ESD) related to synthetic or artificial turf/crumb rubber products. The objective of this memorandum is to summarize information from the literature related to the potential health risks associated with artificial turf and crumb rubber products and material. The review is intended to provide information for the proposed installation of artificial turf as part of field improvements at the Former Woodway High School site in Edmonds, Washington.

This memorandum does not present an opinion or professional assessment by EMB Consulting on the use or health effects from artificial turf fields with crumb rubber. It is intended to provide an objective review and summary of the provided literature.

The documents reviewed are presented below, cited by publishing organization, title, date of publication, and a summary of the conclusions related to health risks. I have organized the 32 documents by category of publishing entity, as follows:

- Studies or information provided by or produced for public agencies (14)
- Scientific peer-reviewed journal publications (5)
- Public interest group writings (5)
- Studies conducted or commissioned by the private turf industry (3)
- Periodicals (2)
- Community news (1)
- Legislation (1)
- Product user assessment (1)

Within these groupings I have organized the material by most recent to oldest in an effort to highlight the current state-of-the-research or recent public concern. The documents are presented by type of publishing entity because each category is written for a different population with the information held to a different standard. For example, studies and information provided by public entities are intended to inform the public. Scientific journal articles are written for peer scientists, with a rigorous review of the methods and conclusions. Publications by public interest groups and community news more often present opinions about the issue. The memorandum concludes with a summary of the findings by category of publishing entity.

Documents Reviewed

Public Agency Publications

New York City and Alberta (CAN) Studies of Artificial Turf Safety. March 18, 2015.

- New York City Department of Health and Mental Hygiene document states:
  - chemicals found in crumb rubber are very common in the urban environment.
  - health effects are unlikely from exposure to chemicals found in artificial turf.

- Alberta Centre for Injury Control and Research, Edmonton, Alberta, Canada concluded that the use of tire crumb in playgrounds results in minimal hazard to children and the receiving environment.

State of Connecticut, Department of Public Health, Recent News Concerning Artificial Turf Fields, January 20, 2015

This memorandum was released to address a KOMO news story that aired on May 19, 2014 drawing a link between use of artificial turf fields with crumb rubber and cancer.

- The document reiterates the findings of the State of Connecticut Department of Public Health investigation (2007, summarized below).

- Studies conducted in Connecticut and elsewhere have shown a very low exposure potential from use of artificial turf fields with crumb rubber, less than from typical outdoor sources of pollution.

- The KOMO report does not represent a correlation or causality and thus raises a concern that currently lacks scientific support.

- Based on available data, outdoor artificial turf fields do not represent an elevated health risk.

Consumer Product Safety Commission (CPSC). Appeal Seeking Correction of Information on Synthetic Turf under the Information Quality Act. August 28, 2013.

- A public interest group, Public Employees for Environmental Responsibility (PEER), has asked the CPSC to withdraw 2008 reports and information related to synthetic turf based on PEER's belief that it violated Information Quality requirements.

- Specifically, PEER took issue with the statement by the CPSC that synthetic turf is "OK to install, OK to lay on".

- The CPSC disagreed with the assertions that the information quality requirements were not met. The appeal was denied.

World Health Organization (WHO). International Agency for Research on Cancer (IARC). Monographs on the Evaluation of Carcinogenic Risks to Humans. Carbon Black, Titanium Dioxide, and Talc. 2010.

The IARC monographs present the international state-of-the-science information about confirmed and potential carcinogens.

- Carbon black is currently ranked as possibly carcinogenic to humans.
- There is no information in the IARC monograph related to crumb rubber or artificial turf. Most of the information that supports the listing as carbon black as a possible carcinogen is related to long-term occupational exposures.

WHO. IARC. Identification of Research Needs to Resolve the Carcinogenicity of High-Priority IARC Carcinogens. July 2, 2009.

This document presents the findings of an IARC and National Occupational Research Agenda (NORA) meeting in Lyon, France in 2009. The document does not address crumb rubber or artificial turf, specifically. It does list carbon black and lead as specific compounds for research focus.

New York State Department of Environmental Conservation and New York State Department of Health. An Assessment of Chemical Leaching, Releases to Air and Temperature at Crumb-Rubber Infilled Synthetic Fields. May 2009.

This report presents the findings of a study designed to assess potential environmental and public health impacts from the use of crumb rubber as infill material in synthetic turf fields.

- Levels of chemicals and particulate in the air at synthetic turf fields do not raise a significant health concern, for cancer or non-cancer health effects.
- Leaching of chemicals from the crumb rubber and turf system create no significant impact on groundwater.
- Temperature survey shows significantly higher temperatures on the field than on the regular surface.

Environmental Protection Agency (EPA). The Use of Recycled Tire Materials on Playgrounds and Artificial Turf Fields. A Scoping-Level Field Monitoring Study of Synthetic Turf Fields and Playgrounds. 2009.

This document presents the findings of a limited-scale scoping study to test a study protocol and monitoring methods for generating environmental data associated with the use of recycled tire material on synthetic turf fields and playgrounds. As part of this evaluation, data were collected at a limited number of sites. The full study protocol was implemented at two synthetic turf fields

and one playground. Additional samples were collected at four other synthetic turf fields and a second playground. Sampling sites were located in North Carolina, Georgia, Ohio, and Maryland.

- The document defines study parameters for validity, precision, and reliability.
- Concentrations of PM10 and metals (including lead) measured in air above the turf fields were similar to background concentrations.
- Concentrations of PM10 and metals at the playground site with high play activity were higher than background levels.
- All PM10 concentrations were below National Ambient Air Quality Standards (NAAQS) for PM10 and Lead.
- All VOCs were measured at extremely low concentrations and are typical of ambient air concentrations.
- One VOC associated with tire crumb materials (methyl isobutyl ketone) was detected in the samples collected on one synthetic turf field but was not detected in the corresponding background sample.
- On average, concentrations of components monitored in this study were below levels of concern.

Windward Environmental, LLC. Initial Evaluation of Potential Human Health Risks Associated with Playing on Synthetic Turf Fields on Bainbridge Island. 2008

This document represents a review by toxicologist Michael Johns, PhD of the available scientific literature and publications regarding human health risks associated with synthetic turf fields for Bainbridge Island. He assessed the human exposure routes from playing on the field and runoff. His overall conclusion is provided here:

> *Overall, the balance of the studies reviewed indicate that human health risks from playing on synthetic turf fields is minimal, even though low concentrations of some chemicals have been demonstrated to leach from the tire crumb, or volatilize as vapor.*

West Virginia Department of Health and Human Resources, CDC Health Advisory #00275, Potential Exposure to Lead in Artificial Turf, June 19, 2008.

This is a Centers for Disease Control Health (CDC) Advisory related to lead in turf. Lead was used in the grass blade material in older turf fields as a colorant.

- Artificial turf made of nylon or nylon/polyethylene blend fibers contains 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.
- Some of the fields with elevated lead in either dust and/or turf fiber samples were weathered and visibly dusty

The use of lead in artificial turf in this application has been reduced, if not eliminated, in the last 10 years.

Connecticut Department of Public Health. Technical Fact Sheet – Health Questions about Artificial Turf. October 2007.

This is a public information document that focuses on the potential health effects from playing on artificial turf fields.

- The document provides a summary of gas and particle hazards.
- The public is exposed to these chemicals in other ways.
- The document provides a summary of the literature as of 2007.
- *"Based upon the current evidence, a public health risk appears unlikely. DPH does not believe there is a unique or significant exposure from chemicals that can be inhaled or ingested at these fields. However, there is still uncertainty and additional investigation is warranted."*

The Connecticut Agricultural Experiment Station. Department of Analytical Chemistry. Examination of Crumb Rubber Produced from Recycled Tires. August 2007.

This is a very limited study with a budget of only $2,000. The study objective was to answer the following three questions.

- Is it possible for compounds to volatilize or out-gas from the tire crumbs?
- What compounds are released?
- Can organic or elemental components be leached from the tire crumbs by water?

The study concluded that it is possible for compounds to volatilize out, and identified the following four compounds: benzothiazole; hexadecane; 4-(tert-Octyl)-phenol; and butylated hyroxyanisole. They also found that zinc, selenium, lead, and cadmium can leach out of the material.

This study is a bench test, conducted entirely in a laboratory. It does not evaluate the degree of risk to a human or environmental receptor.

New Jersey Department of Environmental Protection, Preliminary Assessment of the Toxicity from Exposure to Crumb Rubber: its use in Playgrounds and Artificial Turf Playing Fields. June 2007.

The study provided the following conclusions:

- There is insufficient information to perform a complete formal exposure assessment/risk characterization on crumb rubber.
- Sensitization to rubber in the project is plausible.
- There is no obvious toxicological concern that crumb rubber would cause adverse health effects in the normal population.

State of California. Office of Environmental Health Hazard Assessment (OEHHA). Evaluation of Health Effects of Recycled Waste Tires in Playground and Track Products. January 2007.

The playground surfaces were evaluated for the release of chemicals that could cause toxicity in children following ingestion or dermal contact. Three routes of child exposure to chemicals in the rubber were considered: 1) ingestion of loose rubber tire shreds (acute exposure), 2) ingestion via hand-to-surface contact followed by hand-to-mouth contact (chronic exposure), and 3) skin sensitization via dermal contact (acute exposure).

- Evaluation of toxicity due to ingestion of tire shreds based on the existing literature: Unlikely acute health effects. Estimated cancer risk was well below one in a million.
- Evaluation of toxicity due to ingestion of tire shreds based on gastric digestion simulation: Unlikely acute health effects. Estimated cancer risk was well below one in million.
- Evaluation of toxicity due to chronic hand-to-surface-to-mouth activity: Unlikely acute health effects. Estimated cancer risk was slightly above one in a million.
- Testing for skin sensitization by playground surfaces made of recycled tires: These surfaces would not cause skin sensitization in children, nor would they be expected to elicit skin reactions in children already sensitized to latex.
- Evaluating the potential for damage to the local environment and ecology: Shredded tires used in applications above the ground water table, as is the case for playground surfaces, produced no toxicity in sentinel species.

Norwegian Pollution Control Authority. Measurement of Air Pollution in Indoor Artificial Turf Halls. November 30, 2005.

The study was limited to indoor turf fields.

- Comparison of three specific products for airborne dust, VOCs, and PAHs.
- The results indicate that the use of rubber granulate from ground car tyres causes a considerable burden on the indoor environment.

Scientific Journal Publications

Risk Analysis. Bioaccessibility and Risk of Exposure to Metals and SVOCs in Artificial Turf Field Fill Materials and Fibers (Volume 34, No. 1, 2014). June 11, 2013.

This study evaluates potential exposures from playing on artificial turf fields and associated risks to trace metals, SVOCs, and PAHs to examine typical artificial turf fibers, different types of infill, and samples from actual fields.

- PAHs and SVOCs below detection limits.
- Metals exposure to infill and artificial turf considered *de minimus*, with the exception of lead.

Journal of Toxicology and Environmental Health (Volume 74, Issue 17, 2011). Synthetic Turf Field Investigation in Connecticut. [abstract only] 2011.

The primary purpose of this study was to characterize the concentrations of volatile organic compounds (VOC), semivolatile organic compounds (SVOC), rubber-related chemicals such as benzothiazole (BZT) and nitrosamine, and particulate matter (PM(10)) in air at synthetic turf crumb rubber fields.

- Results showed that personal concentrations were higher than stationary concentrations and were higher on turf than in background samples for certain VOCs. In some cases, personal VOC concentrations from natural grass fields were as high as those on turf.
- Nitrosamine air levels were below reporting levels.
- PM(10) air concentrations were not different between on-field and upwind locations.
- All bulk lead (Pb) samples were below the public health target of 400 ppm.

Journal of Toxicology and Environmental Health (Volume 74, Issue 17, 2011). Human Health Risk Assessment of Synthetic Turf Fields Based Upon Investigation of Five Fields in Connecticut. [abstract only] 2011.

The State of Connecticut investigated emissions associated with four outdoor and one indoor synthetic turf field under summer conditions. On-field and background locations were sampled

using a variety of stationary and personal samplers. More than 20 chemicals of potential concern (COPC) were found to be above background and possibly field-related on both indoor and outdoor fields. These COPC were entered into separate risk assessments (1) for outdoor and indoor fields and (2) for children and adults.

- This study found that outdoor and indoor synthetic turf fields are not associated with elevated adverse health risks.

- The results are consistent with the findings of studies conducted by New York City, New York State, the EPA, and Norway.

International Archives of Occupational and Environmental Health. Hydroxypyrene in Urine of Football Players after Playing on Artificial Sports Field with Tire Crumb Infill. September 25, 2009.

This study was performed to assess the exposure of football (soccer) players to polycyclic aromatic hydrocarbons due to sporting on artificial ground with rubber crumb infill.

- Hydroxypyrene is a PAH, and was used as a marker for PAH uptake.

- This study provides evidence that uptake of PAH by football players active on artificial grounds with rubber crumb infill is minimal. If there is any exposure, then the uptake is very limited and within the range of uptake of PAH from environmental sources and/or diet.

Cancer Causes Control. Occupational Exposure to Carbon Black and Risk of Cancer (Volume 15. No 5). June 2004.

This study was conducted to investigate cancer risk in dockyard workers exposed to carbon black in Genova, Italy.

- Carbon black exposure linked to bladder cancer in dockworkers in Genova, Italy.

Public Interest Group Documents

Center for Environmental Health (CEH). A Cocktail of Harmful Chemicals in Artificial Turf Infill. Not Dated.

The CEH is a public advocacy group with a stated mission to protect people from toxic chemicals. The CEH does not conduct or commission any of its own scientific research. This short article raises concerns about health impacts to children from artificial turf infill.

Dr. Landrigan Curriculum Vitae, not dated

Mount Sinai Pediatrician who has raised concern over the use of crumb rubber and artificial turf.

Mount Sinai Children's Environmental Health Center, What to Know about Artificial Turf, 2011.

This document is a two-page public health information flyer about health risks of playing on artificial turf fields. The document was produced by Dr. Landrigan's organization.

- Proven hazards are heat and friction abrasions.
- Chemical exposures are not known.
- Concerns about artificial turf are primarily the heat effects, the variability of crumb rubber composition, the risks of exposures due to frequent hand to mouth behavior in young children, and the lack of research addressing multiple exposures to vulnerable populations including children.

Environment and Human Health, Inc. (EHHI). Artificial Turf: Exposure to Ground Up Rubber Tires – Athletic Fields, Playgrounds, Garden Mulch. 2007.

EHHI is a public advocacy group stating that they are dedicated to protecting human health from environmental harms through research, education and promotion of sound public policy.

- EHHI does not conduct any of its own scientific research.
- For this publication, EHHI relies on the very limited $2,000 study conducted by the Connecticut Agricultural Research Station in 2007.
- EHHI lists the following theoretical risks from using artificial turf fields:
  - Severe irritation of the respiratory system
  - Severe irritation of the eyes, skin and mucous membranes
  - Systemic effects on the liver and kidneys
  - Neurotoxic responses
  - Allergic reactions
  - Cancers
  - Developmental effects

Environmental Research Foundation. Rachel's Democracy and Health News #956. Hazardous Chemicals in Synthetic Turf: A Research Review. December 13, 2007.

The Environmental Research Foundation was a public advocacy group with a mission of environmental justice and sustainability. They are no longer publishing, but maintain their website as an archive of former articles.

- Hazardous chemicals are clearly present in synthetic turf rubber granules that are made from recycled tires.

- Some metals in the granules, including zinc, leach into water and, if they behave like the metals in other rubber tire material, they can kill aquatic life. However, it is not yet clear whether this leaching presents a health risk to humans and other species in ordinary life conditions.

- It also is unclear whether the various toxic chemicals in the rubber granules can be absorbed into the bodies of children and athletes through inhalation, ingestion, or skin contact. Much more research is needed.

- Although some reports have concluded that the risks are minimal, such conclusions are premature.

Private Turf Industry Studies

Teter Engineering, Analysis of Crumb Rubber Infill, SprintTurf, March 17, 2015.

Two crumb rubber infill samples were analyzed for total metals, total SVOCs/PAHs, leachable metals, and leachable SVOCs/PAHs.

- The concentrations of metals detected in the samples fall below the California soil screening levels (CHHSLs) for unrestricted land use, which are highly conservative for a recreational use scenario.

- Although PAHs were detected in both crumb rubber infill samples, the additional cancer risk from exposure during a recreational use scenario is estimated to fall below the EPA *de minimus* risk level of 1:1,000,000.

- The additional cancer risk from exposure to PAHs in crumb rubber was indistinguishable from the additional cancer risk from exposure to background levels of PAHs and arsenic in rural and urban surface soils.

Playground Professionals News Center. New Independent Lab Testing of Synthetic Turf Crumb Rubber Infill Reconfirms Health and Safety. November 25, 2014.

This report provides the result of independent testing of a field at Lower Canada College by a French laboratory.

- The study concluded that their new synthetic turf field is "safe for continued use by children of all ages".

Ardea Consulting. An Assessment of Environmental Toxicity and Potential Contamination from Artificial Turf using Shredded or Crumb Rubber. March 28, 2006.

This was a toxicological study commissioned by Turfgrass Producers International. It was one of the earliest studies. The study concluded that there was insufficient data to draw conclusions related to the theoretical toxicity of artificial turf fields with crumb rubber.

Periodicals

Scientific American. Study Says Carbon Nanotubes as Dangerous as Asbestos. May 20, 2008.

This magazine article identifies a risk from carbon nanotubes that may have similar properties and health effects as asbestos. There appears to be no direct link between carbon nanotubes and artificial turf or crumb rubber. Carbon nanotubes are specialized microparticles designed and constructed for specific applications. The rubber in crumb rubber is a crude product made from ground up tires, with relatively large particle sizes. There is no link that I can find between carbon nanotubes and crumb rubber.

Environmental Health Perspectives. Synthetic Turf – Health Debate Takes Root. March 2008.

This article provides a summary of the issues as of 2008.

Community News/Blog Journalism

The Heights Observer. Play it Safe with Artificial Turf. January 31, 2013.

This community newspaper from Cleveland Heights, Ohio introduces the debate related to artificial turf. The article references the concerns noted by Dr. Landrigan.

Legislation

State of California, Senate Bill No. 47, December 17, 2014.

This bill would require the Office of Environmental Health Hazard Assessment to prepare a study analyzing synthetic turf for potential adverse health impacts.

Other

Federation International Football Association (FIFA). An Open Letter concerning the potential cancer risk from certain granulate infills from artificial turf. July 12, 2006.

- FIFA conducted a review of available data.

- They concluded that the studies to date have concluded that "PAHs [Polynuclear Aromatic Hydrocarbons] are not released or at most negligibly released from tyre abradate" (The University of Dortmund Institute for Environmental Research 1997). Epidemiological studies conducted by the Health Effects Institute, The World Health Organization and other investigators do not implicate tyre wear particles in ambient air as contributing to human health effects (respiratory and cardiovascular diseases)

Summary of Literature Review

The documents provided for review by the ESD offered a broad perspective on the issues of actual and theoretical health risks associated with artificial turf fields with crumb rubber. For the purposes of this memorandum, actual health risks are those that are not disputed and are based on scientific or physical evidence. Theoretical health risks are those that seem plausible, but are not yet substantiated by scientific or physical evidence. The documents include:

- Studies and information bulletins issued by international, federal, state, and municipal regulatory agencies and departments;
- Studies published in scientific journals, conducted by academics, and funded by public sources;
- Studies commissioned by industry groups;
- Opinions issued by public interest groups and turf users; and
- Journalism sources, to include periodicals, web postings, and newsletters.

Some of the documents illustrated the advantages of artificial turf fields over grass fields for safety and environmental benefits, as summarized:

- artificial turf fields require reduced water usage;
- installation of artificial turf fields may result in overall reduced costs and effort to maintain;
- artificial turf fields may avoid the use of pesticides, herbicides, and other lawn chemicals required to maintain a grass field;
- the extra cushion provided by artificial turf fields may reduce the frequency or severity of fractures and other traumatic injuries;
- artificial turf fields offer the ability to play on the field during a variety of weather conditions; and
- artificial turf fields provide a recycling alternative for the vast stockpile of waste tires.

Some documents highlight what can be considered actual health risks or hazards associated with playing on artificial turf fields with crumb rubber. These actual hazards were described in the Mount Sinai Hospital information document. These include:

- Artificial turf field surfaces can develop elevated heat relative to natural surfaces, which may create a condition of discomfort for athletes. This condition only exists during high ambient temperature periods.

- Athletes who fall on artificial turf fields can have friction burns or turf abrasions, which can be more severe than what would occur on natural surfaces.

The larger issue, and one much more difficult to manage and address, are the theoretical risks associated with artificial turf and crumb rubber. The theoretical risks are assigned by theory based on the materials present in the artificial turf and crumb rubber and what is known about these chemicals in other applications. The chemicals and properties of concern associated with artificial turf and crumb rubber are:

- Volatile organic compounds and semi-volatile organic compounds, such as benzothiazole, hexadecane, 4-(tert-Octyl)-phenol, and butylated hyroxyanisole;

- Polynuclear aromatic hydrocarbons, such as hydroxypyrene;

- Metals, such as lead, zinc, selenium, and cadmium. It should be noted that the use of lead chromate in new artificial turf has been greatly reduced compared to earlier field materials;

- Carbon black, which is a petroleum product formed by incomplete combustion of heavy petroleum products and which accounts for an estimated 80 percent of tire mass;

- Particulate, usually studied in crumb rubber studies as PM-10, but also referenced in the documents in nano-particulate size.

Cancer is the most frequently cited theoretical adverse health outcome. The 2014 KOMO news report focused on the incidence of cancer among soccer goalies and time spent on artificial turf fields with crumb rubber. There does not appear to be any scientific evidence or causal link to corroborate the findings in the KOMO report.

Studies that appear to exhibit rigorous scientific validity find no additional risk from the chemicals or physical properties of artificial turf and crumb rubber. Many of the studies note that the chemicals are already prevalent in our environment. The addition of exposures from turf fields with crumb rubber do not appear to increase risk above what is already present in the population.

The documents acknowledge that health assessments of artificial turf fields with crumb rubber are made more complicated by a number of factors:

- the variety of material used in the products;

- the variety of applications. For example, artificial turf with crumb rubber on indoor fields appears to have more evidence of potential exposures without the advantage of natural ventilation and dilution; and

- the age and condition of the field material.

The studies acknowledge that turf field materials contain hazardous constituents and that the public, notably children, are in contact with these hazardous constituents. What has not been demonstrated, however, is an exposure pathway by which the constituents can enter the body of the field users and do damage or initiate disease. For a hazardous material to actually present a risk for the end user there has to be a pathway of exposure and a way for the chemical to do damage.

One of the chemicals proposed as a hazardous constituent of crumb rubber illustrates this point. Carbon black is classified by the IARC as possibly carcinogenic to humans. Most of the data available linking carbon black to cancer comes from occupational studies, where workers were exposed to high concentrations of fine carbon black dust for many years. The studies evaluated during this review did not document the presence of fine particulate or specifically identify carbon black. It appears likely that the carbon black in artificial turf/crumb rubber systems remains bound in the relatively large chunks of tire rubber, making it unavailable for distribution as a fine dust and therefore unavailable for uptake by the field users. Based on the scientific research, there is neither the dose, nor the exposure route, to indicate a health hazard for artificial turf/crumb rubber field users.

All studies acknowledge that additional data is needed to more fully assess potential exposures and possible health risks associate with the use of artificial turf fields with crumb rubber. In the meantime, leading public health agencies, such as the EPA and Consumer Product Safety Commission, are supporting continued use of artificial turf fields with crumb rubber.

Please call me if you have any questions about the information provided.

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