HSWMR

Hazardous Substance & Waste Management Research, Inc.

2976 Wellington Circle West
Tallahassee, Florida 32309
Phone: (850) 681-6894
Fax: (850) 906-9777
www.hswmr.com

May 20, 2014

Mr. Michael P. Crotty
Town Manager
Town of Surfside
9293 Harding Ave.
Surfside, FL 33154

Dear Mr. Crotty:

This letter report represents my technical analysis and conclusions regarding arsenic that was reported from samples of sand used for beach renourishment at the Surf Club in the Town of Surfside, Miami-Dade County, Florida. My specific conclusions, as detailed in the letter are:

- *the chemical analysis of the sand samples for arsenic is consistent with natural background for this and other areas of coastal Florida, as indicated by a body of sampling data from a number of reputable sources. Such background ranges from less than 1 mg/kg to over 15 mg/kg in Miami-Dade County with a central tendency estimate of 5.2 mg/kg. Samples collected from renourishment sand fall in the middle of that background range;*

- *there are not significant health risks posed to children, to adults, or to pets by the observed background concentrations of arsenic in beach sand; and*

- *available evidence supports the conclusion advanced by the Florida Department of Environmental Protection (DEP) and Terracon Consultants that the sand is "beach compatible", as judged by measures of grain size analysis and color.*

The technical bases for these conclusions are provided in detail in the following sections. In preparation of this analysis, I have reviewed a wide spectrum of information sources, including the following:

- Beach sand chemical testing data, Town of Surfside, from Terracon Consultants, Inc. as reported May 5 and May 9, 2014 (Terracon, 2014a; Terracon, 2014b);

- Correspondence and supplementary material from Dr. Samir Elmir, Florida Department of Health in Miami-Dade, to Michael P. Crotty, Town Manager, Town of Surfside, dated May 14, 2014, regarding arsenic concentrations in beach sand at the Surf Club location (FDOH, 2014);

- Correspondence and supplementary material from Florida Department of Environmental Protection (DEP; 2014);
- Review of information and personal communication with Mr. Wilbur Mayorga, P.E., Chief of the Environmental Monitoring and Restoration Division of the Miami-Dade County Department of Environmental Resources Management (DERM) regarding natural and anthropogenic (human-related) background arsenic concentrations in Dade County soils and sediments, including coastal beaches;
- Sand test summary dated May 13-14, 2014, Town of Surfside (Surfside, 2014);
- Scientific literature and technical reports addressing the issue of naturally occurring or anthropogenic arsenic concentrations in Florida soils and marine sediments/sands; and,
- Scientific literature and technical reports regarding health-based guidelines for potential exposures to arsenic.

My Summary and Conclusions, presented at the end of this letter report, are directed toward an evaluation of the extent to which the available sampling data permit a conclusion that arsenic detected in renourishment beach sand represents a naturally occurring circumstance, as well as the potential risk that may be posed by the observed conditions.

Historical Perspective and Data Presentation

Laboratory analysis was performed on a sample of beach sand/sediment collected in late-April, 2014, related to a beach renourishment project conducted in the Town of Surfside near the Surf Club (Terracon, 2014a; Attachment 1 shows chemical sample locations). The sand sample was analyzed for Total Recoverable Petroleum Hydrocarbons (TRPH), as well as arsenic, aluminum, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. Only the arsenic concentration of 8.9 milligrams per kilogram (mg/kg) in the sand sample exceeded its default residential Soil Cleanup Target Level (SCTL) of 2.1 mg/kg, as set by the Florida Department of Environmental Protection (DEP, 2005; Terracon, 2014a). ***As discussed subsequently in this letter report, the 2.1 mg/kg guideline assumes simultaneous oral, dermal, and inhalation exposure for 350 days/year and for 30 years, including both children and adults. That level represents a conservative, acceptable health-based target level with a reasonable margin of safety that is quite unlikely to underestimate risks.*** Other protective values are available for comparison.

On May 6, 2014, a Terracon representative collected two additional samples of beach sand within the renourishment area from a depth of 0 to 12 inches at a point approximately 8 feet south and 4 feet east of emergency pole #16 at 88th Street and at a point 12 feet south and 5 feet east of emergency pole #5 at 94th Street for laboratory chemical testing (Terracon, 2014b). The two samples were analyzed for all of the same parameters as the initial sand sample. Arsenic concentrations in the two samples were 7.0 and 7.8 mg/kg, both of which exceeded the DEP arsenic default residential SCTL of 2.1 mg/kg. Terracon (2014b) concluded that, based on the similarity of the arsenic concentrations among the samples and the close proximity of the measured values to those reported in the literature as background for the local area, the measured concentrations reflected a background condition.

Based on evaluation of the Terracon data, the Florida Department of Health (FDOH) concluded that there was not a significant increased health risk related to exposure to arsenic in the beach sand, even assuming lifetime exposure (FDOH, 2014). The FDOH statement supplemented the conclusions of Dr. Samir Elmir, Ph.D, P.E., Director of Environmental Health & Engineering Services for the Florida Department of Health in Miami-Dade. In addition, Mr. Wilbur Mayorga, P.E., Chief of the Environmental Monitoring and Restoration Division of the Miami-Dade County Department of Environmental Resources Management (DERM) has concluded that the test results are consistent with naturally occurring arsenic levels on the barrier island beaches in Miami-Dade County, which showed a Minimum Variance Unbiased Estimate (MVUE) of 5.2 mg/kg and a maximum of 15.1 mg/kg (Mayorga, 2004; Mayorga, 2014; Surfside, 2014). Naturally occurring background is indicative of conditions that are geological in origin and do not represent human activities.

While it is not strictly a toxicological issue or a human health risk issue, it is worth noting that both the Florida Department of Environmental Protection (DEP) and Terracon have evaluated the morphological and physical characteristics of the sand that was used in the Surfside beach renourishment project (DEP, 2014; Terracon, 2014c). Those entities independently concluded that the objective testing results indicate the beach sand to be of suitable quality, similar to native beach materials, and compatible with the existing regulatory requirements, both prior to and subsequent to the renourishment permit being issued. It may be that the coloration of the sand would differ somewhat on a temporary basis from pre-project surface beach sand. However, natural processes (e.g., sunlight, wind and wave action grain size sorting, rainfall, foot traffic) can be expected to cause the beach to regain its relatively consistent appearance over time.

Arsenic in Soils and Marine Sands as a Natural Background Issue

Natural background concentrations of arsenic in Florida soils have been reported to range from less than one mg/kg to greater than 60 mg/kg, depending upon soil type and geographic location in the state (e.g., Brinkman and Ryan, 1998; Chen et al., 1999a;

Chen et al., 1999b; Chen et al., 2001; Gustavsson et al., 2001; Ma et al., 1997; Mayorga, 2004; Miami-Dade County, 2014). These soil types include upland environments, wetlands, and materials derived from aquatic environments (e.g., sediments, beach sand).

The natural occurrence of arsenic in the aquatic environment is commonly associated with marine organisms and the shelly, sedimentary layers that are of marine origin (Lunde, 1977; Cai et al., 2002), and uncontaminated coastal area marine sediments regularly contain from about 5 to 15 mg/kg arsenic (Neff, 1997; Moore and Ramamoorthy, 1984). Background sediments from Biscayne Bay and other Florida estuaries or coastal areas contain natural background levels of arsenic ranging from less than 10 mg/kg to over 60 mg/kg (Schropp and Windom, 1988; Windom et al., 1989; Schropp et al., 1990; USEPA, 2001). Valette-Silver et al. (1999) collected sediments from Biscayne Bay near the mouth of the Miami River and reported an average arsenic concentration of 5.1 ug/g (5.1 mg/kg), with a range of about 3 to 23 mg/kg. Those authors also sampled bivalve molluscs (oysters or mussels) from local Florida coastal waters, reporting arsenic concentrations in those specimens from approximately 5 to 65 mg/kg. Finally, the authors reported a median unadjusted total arsenic value of 16 mg/kg for southeastern U.S coastal sediments. Similar observations have been made regarding sediments in other states along the U.S. East Coast (e.g., NJ; see Barringer et al., 2013).

There seems to be little doubt or disagreement that the results presented for the Surfside beach samples are consistent with generally expected arsenic levels in Florida soils/sediments that may be characterized by limestone deposits and coastal marine, seashell-derived material. Based on results of a DEP-sponsored study of different soil types across the state (Chen et al., 2001; Chen et al., 2002) and a Miami-Dade County study of beaches and coastal barrier islands sands (Mayorga, 2004), the arsenic concentrations in the Surfside beach sand are consistent with local naturally occurring background conditions. That is, they are the natural concentration ranges that would exist even if no human beings were present.

Human Health Considerations

A variety of national and international environmental and health organizations, as well as independent toxicologists, have evaluated the occurrence, exposure potential and toxicology of environmental arsenic forms (e.g., ATSDR, 2007; Hughes et al., 2011; NAS, 2014; USEPA, 2005; USEPA, 2007). Those scientific and health-based assessments have concluded that, while arsenic certainly has the capability in some circumstances to cause adverse health effects, the likelihood of such effects is strongly influenced by important aspects of the observed arsenic concentration, chemical form, and exposure potential.

Because arsenic is naturally occurring and ubiquitous in the environment at various concentrations, humans are exposed to the substance from a number of sources, including through our normal diet (Adams et al., 1994; ATSDR, 2007; ATSDR, 1990; Borum and Abernathy, 1994; USEPA, 2005; USEPA, 2007; WHO, 2001). ATSDR (2007) states that the highest dietary levels of arsenic are found in seafood, meats, and grains. Typical U.S. dietary levels of arsenic range from 0.02 mg/kg in grains and cereals to 0.14 mg/kg in meat, fish and poultry (Gartrell et al., 1986). Shellfish and saltwater fish typically contain the highest levels of total arsenic (average about 4 to 5 mg/kg, maximum up to 170 mg/kg). It has been observed that the organic arsenic forms which are typically present in seafood can dramatically elevate arsenic levels in human urine, though these organic arsenic forms are generally considered to be less harmful than inorganic arsenic forms at similar concentrations. Common foods which contain more than 50 micrograms of arsenic/kilogram of food (ug/kg; a microgram is one millionth of a gram) include tuna (fresh, canned, and casserole), fish sticks, fried shrimp, fried haddock, clam chowder, turkey breast, rice, mushrooms, and olive oil or safflower oil (Adams et al., 1994). A substantial portion of the arsenic in fish tissue is present in the essentially nontoxic trimethylated form known as arsenobetaine (90-100% of fish arsenic; Nriagu, 1994); however, dairy products, meat, poultry, and cereals contain a majority of their arsenic in an inorganic form (Borum and Abernathy, 1994). There is good evidence that arsenic actually may be a necessary human nutrient at some level in some species, because it appears to play an essential role in the normal metabolic processes of man and other mammals (ATSDR, 2007; NRC, 1989; Uthus, 1994; Uthus, 1997; USEPA, 2014a). However, a recommended daily intake quantity for arsenic in any form has not yet been established.

When all the sources of exposure (food, water, air, and soil) are combined in an intake analysis, the ATSDR (2007) estimated that the U.S. general population consumes on the order of 46 micrograms of arsenic per day (46 ug/day), most of which is in organic forms. Borum and Abernathy (1994) calculated that humans ingest between 10 and 20 ug of inorganic arsenic per day, and the Agency for Toxic Substances and Disease Registry (ATSDR, 1990) put this figure at an average of 50 ug/day (range 8 ug/day to 104 ug/day), of which about 30% is in the inorganic form (~70% organic forms). People who eat large amounts of seafood may consume 50 ug or more of arsenic per day from that food source alone (Adams et al., 1994). Cigarette smokers typically are exposed to higher arsenic quantities than the general population due to its presence in tobacco products.

The significance of arsenic contact and subsequent intake differs according to the route of potential exposure (ATSDR, 2007; Hughes et al., 2011; Teaf and Covert, 2012). From an environmental perspective, particularly regarding exposure to soils and sediments, the oral route is the principal consideration, and it dominates the calculation of protective exposure limits. The dermal pathway and the inhalation pathway contribute much less for separate reasons. Dermal absorption of arsenic is considerably less efficient than oral absorption, and airborne arsenic in association with soils, even in situations where the soils are uncovered and subject to wind erosion, typically represents a minor intake route.

As a point of reference for the sand data characterization as described previously, a discussion of the Florida Department of Environmental Protection (DEP) Soil Cleanup Target Level (SCTL) is warranted. It must be recognized that the type, frequency, and intensity of potential exposure, not just the concentration of a substance in soil, is critical to an appropriate evaluation of potential health risks. In that regard, the default residential SCTL is not strictly an appropriate criterion to use for potential beach exposures, since residents don't actually live on the beach itself, though they may visit very frequently. That SCTL value often is cited as an appropriate guideline for comparisons to all types of soil samples, though in this instance that is not appropriate.

The present default direct exposure residential SCTL for arsenic is 2.1 mg/kg (DEP, 2005), a value which is based on a 30 year unrestricted childhood/adult aggregate residential exposure scenario which assumes a soil ingestion rate of 120 mg/day for 350 days/year and a target cancer risk of 1×10^{-6} ("one–in-one-million"; a population increase of one cancer in one million individuals beyond the baseline expected cancer rate, assuming that lifetime exposure occurs). The DEP process, and that of other toxicologists as well, simultaneously considers that there is a possibility of a "childhood only" exposure scenario, typically assuming an age range up to six years. Considering daily exposure for that entire childhood period, and addressing potential noncancer health effects for arsenic, the childhood scenario yields a protective arsenic soil concentration of 78 mg/kg, a value much greater than the 7.0 to 8.9 mg/kg concentration that has been reported for the beach sand. Thus, children are not at significant risk. Because agencies, in this case DEP or Miami-Dade DERM, use the more restrictive of the two possible exposure scenarios, the 2.1 mg/kg value becomes the default, even though a considerably less restrictive concentration is specifically protective of a childhood scenario. Similarly, in response to potential concerns that toxic effects from arsenic aside from a cancer risk may represent a hazard, a scenario which considers only potential noncarcinogenic effects for the 30 year childhood/adult residential soil exposure circumstance yields a protective concentration for arsenic in excess of 400 mg/kg. Again that value is far greater than the concentrations observed in the beach sand, demonstrating that other possible effects from arsenic are not significant.

DEP also has developed a direct exposure SCTL of 12 mg/kg for arsenic where contact is expected to occur under commercial/industrial circumstances (DEP, 2005). This scenario is based on 25 year adult worker exposure considerations, assuming the potential for oral, dermal, and inhalation routes of exposure, with a soil ingestion rate of 50 mg/day for 250 days/year and a target cancer risk of 1×10^{-6}. The commercial/industrial criterion, while the exposure assumptions may be somewhat more comparable to beach sand ingestion exposure in terms of frequency, also would not be entirely appropriate since the ancillary exposure pathways (i.e., inhalation, dermal contact) are not comparable between workers and beachgoers (more intense for commercial/industrial).

Finally, DEP has developed and employed a provisional recreational exposure scenario for arsenic of 5.5 mg/kg (DEP, 2006), based on a conservative child/adolescent exposure scenario of 14 years duration, assuming all three exposure routes, a soil ingestion rate of 129 mg/day for 200 days/year, and a target cancer risk goal of $1x10^{-6}$. That 5.5 mg/kg value, or similar numerical guidelines, has been applied at sites with various nonresidential, recreational aspects, such as rails-to-trails facilities, parks, and schools in Florida.

The provisional recreational "park" criterion is conceptually the most applicable in this instance, with the understanding that a single criterion may not encompass the range of potential exposures, since beach use is highly variable. As noted, DEP has used a similar scenario in evaluating potential school facilities as well in the past, and the exposure parameters for adults are most similar to the conservative commercial industrial exposure scenario (e.g., 5 days per week, 50 weeks per year, 25 years duration, with oral/dermal/inhalation possibilities). The detected arsenic concentrations in the renourishment beach sand at Surfside are in the range of both the provisional recreational criterion and the default commercial/industrial guideline. This indicates that there is not a significant health risk from exposure to those levels of arsenic in the sand. In that conclusion, I concur with the previously identified opinions of the Florida Department of Health representatives.

It also should be noted that a review of 35 states other than Florida that report a residential cleanup target or health-based protective criterion for arsenic in soil, shows that at least 20 of those states utilize a default screening target concentration that exceeds 2.1 mg/kg, with values ranging from 3.9 mg/kg to 24 mg/kg. In addition, the states of AZ, CT, IL, IA, KS, KY, MA, MN, MO, NH, NJ, NY, PA, RI, WA employ protective soil cleanup guidelines ranging from 7 to 40 mg/kg, based upon natural background considerations (Teaf et al., 2010; Teaf and Covert, 2012). At a number of Florida sites, the U.S. EPA has implemented soil cleanup targets of 20 mg/kg or greater in residential or other unrestricted land use circumstances. Thus, while the Florida DEP and some local jurisdictions have exercised their prerogative to set a highly conservative guideline with respect to default protective soil arsenic concentrations, an exceedance of the 2.1 mg/kg residential criterion does not indicate that hazards to human health exist.

As an example of the foregoing, a study was conducted in Florida by the Department of Health in partnership with the federal Agency for Toxic Substances and Disease Registry (FDOH/ATSDR, 1996b). That study involved the Barker Chemical Site in Inglis, in Levy County, FL. The site was an inactive chemical facility that formerly produced phosphate fertilizer from ore that had an elevated arsenic content. Disposal of waste from that facility resulted in soil in some residential areas that was contaminated with relatively high levels of arsenic. Preliminary studies of soil in residential areas of Inglis revealed arsenic concentrations up to 3,000 mg/kg. Other studies undertaken by the U.S. EPA at Inglis detected arsenic concentrations in soil up to 687 mg/kg in residential areas (FDOH/ATSDR, 1996a). The Florida Department of Health performed both hair and urine analysis for arsenic for 25 residents of the area including children, who were judged to have had the greatest exposure potential to soils. The Department of Health reported no detectable arsenic in over 83% of urine samples, with the detected values being within the normal reference range (<50 ug arsenic/gram creatinine) for those where it was detected. Similar results were found for the analysis of arsenic in hair samples. The Florida Department of Health concluded that none of the test participants had results indicating excessive exposure to environmental arsenic and recommended that no further public health activities were warranted. Thus, even at relatively extreme arsenic soil concentrations, persistent exposure and absorption could not be demonstrated. Other studies in states where arsenic in soils is naturally elevated have yielded similar results for adults and children, demonstrating very limited potential risks from soil exposure (Boyce et al., 2008; Teaf et al., 2010).

Occasionally a question is posed regarding contact by pets in the context of soil exposure. I am not aware of evidence to suggest that cats, dogs, or other pets are more sensitive to arsenic than human beings. In fact, metabolic data for dogs and humans suggest that humans are the more sensitive species (Hughes et al., 2011). Background soil concentrations, or levels set for protection of humans, are considered to be protective of pets as well.

In the interest of addressing as many potential questions that have been raised related to health issues as possible, let me also touch on the subject of radon. Radon is an odorless, colorless, low level radioactive gas that can be associated with some types of soils in Florida and elsewhere in the U.S. It forms naturally from the decay of other radioactive elements. Radon has been the subject of extensive research by U.S. EPA and other public health agencies in connection with potential indoor air exposures and cancer concerns. Radon in outdoor air typically is very low, in the range of 0.4 picocuries per liter of air (pCi/L), and it has not been identified as a health issue in outdoor circumstances in Florida (FDOH, 2013; American Cancer Society, 2013). I am not aware of any agencies that address radon in outdoor air, or recommend that it be tested, and the stated goal of U.S. radon requirements is that indoor levels be no more than what would be present in outdoor air (USEPA, 2014b). I have not seen any circumstance for which radon has been measured in outdoor air at a beach environment.

Summary and Conclusions

The observed concentrations of arsenic in the renourishment beach sand tested near the Surf Club in the Town of Surfside, and the similarity between those concentrations and local background arsenic concentrations, demonstrates a condition consistent with naturally occurring sources. The observed arsenic concentrations, when coupled with an understanding of potential exposure circumstances related to the beach sand and a comparison to various health-based concentrations of the substance, do not represent a significant human health risk in these circumstances.

Please call Bruce Tuovila or me at (850) 681-6894 when you have had an opportunity to review these materials, so we can address any questions or comments that you may have.

Sincerely,

Christopher M. Teaf

Christopher M. Teaf, Ph.D.
President & Director of Toxicology

CMT:bt

Attachments (2)

Attachment 1 *Figure Showing Sample Locations for Chemical Analysis*
Attachment 2 *References Cited*