June 27, 2013

Ms. Susan Lee
Planning Department
Matanuska Susitna Borough
350 E. Dahlia Avenue
Palmer, AK 99645-6488

Re: Hydrogeologic evaluation of a proposed monofill, Palmer, Alaska

Dear Ms. Lee:

This letter is to provide the findings of my recent review of data and reports related to a hydrologic evaluation of a proposed monofill consisting primarily of shredded construction and demolition (C & D) waste near Palmer, Alaska.

I have reviewed the on-line packets for the June 3 and June 17 meetings and relevant portions of the audio recording of the June 3 and June 17 public hearings.

You have requested that I provide:

- a summary of the concerns that the proposed monofill will raise regarding the water table;
- potential negative effects to the groundwater and down-gradient drinking water wells, and;
- characterization of the aquifer at risk – in layman's terms.

In addition, you would like me to review a June 14, 2013, letter from Central Monofill Services (CMS) and evaluate their section on "Protection of the Aquifer".

**Summary of concerns that the proposed monofill will raise regarding the water table.**

This section refers primarily to concerns and processes occurring within the site boundaries and at the water table beneath the waste. There are several features of the proposed monofill that merit examination, including:

- expected water flow through the waste;
- the concept of a natural soil liner at this site;
- the proposed 10-ft separation buffer to the water table;
- the expected time of travel of water or leachate through a 10-ft soil layer; and
- characteristics of waste to be disposed of and potential contaminants that may emerge.

**Expected water flow through the waste.** Review of the design documents, management plans, and public comments for this site shows that there appeared to be no significant effort to reduce or control infiltration of rainfall and snowmelt through the waste. Thus, expected rates of infiltration are expected to be similar to those that occur elsewhere in the surrounding landscape.

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Infiltration, or groundwater recharge, is difficult to quantify with accuracy, however hydrologists commonly assume that approximately 20 to 30 percent of annual precipitation recharges groundwater in areas such as this. Such a percentage would mean that approximately 3 to 5 inches per year of precipitation would infiltrate and percolate downward through the waste. Using an eventual waste area of 30 acres, for example, this would equate to 300,000 to 500,000 gallons per year. Owing to the principal of conservation of mass, this amount of water or leachate would also need to flow out of the waste pile somewhere.

**Low permeability liner.** The public hearings contained considerable discussion of an "impermeable" clay/silt liner.

A review of the engineering drawings and specifications for the site show no provision for an engineered native-soil or other liner. This absence of engineering specification raises doubts about the effectiveness of such a liner. For example, there is no information in the record about the planned thickness, continuity, soil laboratory characteristics, tie-in with lateral boundaries, compaction, inspection, permeability, or numerous other aspects that are normally associated with engineered native-soil liners. There is no information in the record about the quantity of fine-grained material on site and whether there is enough to cover the site. Most of the soil borings on the site show that materials other than clay/silt are present at the land surface at the boring sites. The site has considerable topographic relief. In order for a liner to be effective, it must be continuous. There is no information about the applicant's intent to spread the fines over the higher areas as well as the lower areas.

This means that on-site personnel, whether they be equipment operators or supervisors, may be responsible for field decisions about the sources and spreading of low-permeability material. The apparent absence of any engineered, supervised, or inspected earth-moving process at this site along with the presence of abundant sands and gravels that are known to be present at the site substantially reduces the likelihood of successful construction of a low-permeability liner.

Mr. Young of Terrasat, at the June 3 hearing, commented that the clay/silt materials were "impermeable". A commonly-referenced textbook, Freeze and Cherry (1979), for example, notes that the permeability of clay and glacial till (including silt) can range from $10^{-6}$ to 10 gallons/day/sq. ft, however none of these materials are "impermeable" i.e. meaning completely impenetrable to water. Mr. Young's statement is misleading.

More importantly, however, the concept of placing an "impermeable" liner as described at the hearing at this site is severely flawed. With no impermeable cap, rainfall and snowmelt at this site will readily infiltrate and percolate vertically downward through the waste. Since there is no internal water collection system, this water would encounter the "impermeable" surface and pool up inside the waste. The fluid would then have no place to go except to fill pore spaces within the waste pile and create a perched water table that would rise up into the pile until it found an outlet somewhere around the perimeter. Leachate would then flow out and drain into the surrounding aquifer. The main effect of the impermeable liner would be to prolong the contact time of leachate water with waste material and increase the potential for dissolution of contaminants into the water. After the perched water table becomes established inside the pile, the rate of outflow would be approximately equal to the rate of inflow from recharge and the net effect to the aquifer would be worse than if there was no liner at all.

As a result of the likely failure to construct an effective liner for the reasons described above and the adverse consequences if a liner were emplaced, this analysis will assume that there will be no effective liner for this site.

**10-ft separation barrier and determination of the water-table position.** The applicant proposes to keep a 10-ft separation between the bottom of wastes emplaced and the water table. The water table at this site is not well defined. The applicant has proposed to incorporate more recent water table measurements into facility design, however these measurements are currently unavailable for review, and in any event, do not consider several of the factors described below.

Following are problems with the current definition of the water table as provided on a map dated December 20, 2012 by Terrasat:

- Terrasat, in their August 2012 report, note that soil well logs were logged at different times, and locations may not be accurate or have accurate elevation control to establish the water table. It is not clear whether these problems were resolved for preparation of the December 20, 2012 map inasmuch as there is no report describing data and methods associated with that map. If these problems were not resolved, these would be non-standard and inaccurate methods for defining a water table.

- The measurements on which the existing water table map was produced on Dec. 20, 2012 have not been reported in the record so that it is difficult to verify the accuracy of the contouring.

- The contouring exhibits odd and inappropriate gradients of the water table across two of the ponds. Ponds at this site are considered to be an expression of the water table, and the water table should be flat (i.e. no gradient) at the ponds. The contouring is likely erroneous.

- Normal seasonal variations have not been measured and reported. Peak water-table elevations can occur in late September or early October in the Palmer area, so even springtime measurements would be inadequate to define the peak water table.

- Longer-term wet-year water-table fluctuations have not been analyzed or accounted for.

- The potential effects of changes in the water table caused by the reported recent construction of a weir in the dike separating nearby ponds or further breaches of the dike have not been evaluated (a breach apparently caused a 6-ft water-table rise a few years ago).

- Potential changes in the water table caused by future gravel mining in the area as described by Brailey (2007) and Munter (2010) have not been accounted for. Such gravel mining plans could increase water table elevations at this site by a few feet.

Combining all these factors, the water table map and any as-yet-reviewed updates are concluded to be an unreliable basis for designing a 10-foot water table separation at this facility.

Thus, the design of this facility appears to be insufficient to assure a 10-ft separation from the bottom of the waste to the water table.

**Time of travel of water through 10 feet of soil.** Mr. Young of Terrasat commented at the June 3 hearing that the 10-ft separation distance was not arbitrary – it was based on the length of time that it takes water to flow through it. Since ADEC does not specify that the soil used for the separation distance needs to be of low permeability, this statement has doubtful merit.

For example, using a textbook midrange value for the permeability of clean sand, water under saturated conditions can be expected to flow through a 10-ft layer in approximately 32 minutes. A similar calculation using a typical permeability for silty sand yields a time of travel of about 8 hours. Flow in each scenario would be slower under unsaturated conditions, however it can be readily seen that a 10-ft separation distance in coarse granular materials would yield very little delay-time protection from water migrating vertically downward from waste material into a water table.

An alternate explanation for the separation distance is that studies have shown that landfills that are partially submerged below the water table are generally more prone to leaching and contaminating groundwater as a result of the longer contact times of the waste in contact with water. A 10-ft separation would at least provide some assurance that the wastes will not reside in saturated conditions at most sites. Notably, ADEC allows monofills to be constructed on high-permeability sands and gravels as long as the separation distance is met. Thus, it appears that time of travel is not a significant factor in their evaluation.

**C & D Landfill Leachate.** C & D landfills are very common in the United States because this type of waste is abundant, is perceived as relatively inert, and because these types of facilities are usually subjected to less stringent environmental protections that normal landfills and thus costs of disposal tend to be lower.

The evaluation of leachate contamination to groundwater from C & D landfills appears to be an evolving science. These facilities have commonly been regarded as minimal threats to groundwater because they have been considered to contain relatively "inert" materials. Far from being chemically inert, however, many materials in C & D landfills, including wood and drywall will rot, decay, and leach constituents into groundwater. At least 27 states now require groundwater monitoring from such landfills, in increasing recognition of their potential to contaminate groundwater.

Studies have shown increased concentration of some contaminants from these types of facilities. A study conducted for the U.S. EPA from 1995, for example, (ICF Incorporated, 1995) found groundwater contaminants that exceeded primary or secondary Maximum Contaminant Levels (MCLs) for drinking water at 11 C & D landfills. Potential contaminants from the proposed facility include sulfate, iron, manganese, total dissolved solids, arsenic and other metals, and organic compounds.

Many of the wastes proposed for the monofill, including wood, drywall, carpet, and probably even tire bales are not geologically stable in the Palmer area. Waste breakdown will inevitably result in dissolution and entrainment of waste constituents in leachate.

While the proposed monofill proposes to exclude "Hazardous Waste", it is not clear what this means, and in particular, that all waste that may be hazardous to water supplies will be excluded. For example, it appears that treated lumber containing compounds or elements known to be hazardous to human health appear to be allowable in the waste stream.

The term "Hazardous Waste" has numerous technical definitions that stem from the numerous laws and regulations that govern them. In this case, there will be a reliance on pre-demolition "Hazardous Building Material Surveys" and the proper exclusion of items described therein. The existence, thoroughness, and accuracy of these surveys is therefore important to the process, however it is difficult for the Borough to know or be assured that all materials that are potentially hazardous are appropriately excluded.

An important aspect of water contamination is that only a small amount of some compounds or elements are needed to contaminate a large volume of water. Arsenic, for example, has a drinking water primary MCL of 10 micrograms/liter, or approximately 1 part in 100 million. The waste will be shredded, thus making for a relatively large surface area of waste in contact with percolating waters. It is not unreasonable to expect that even small percentages of leachable wastes in the 2 million cubic yards of waste will result in measurable quantities of contamination.

This is a large facility. Considering that the proposed facility has a planned capacity of 2 million cubic yards of material and will have a service life of over 25 years, it would be reasonable to assume that there will be a sufficient amount of waste accumulated to generate leachate that will exceed one or more drinking water Maximum Contaminant Levels.

There are no significant barriers to the migration of this leachate into groundwater and it is highly likely to result in measurable increases in contaminants beneath the facility and for some distance down gradient.

**Potential negative effects to the groundwater and down-gradient drinking water wells.**

It is prudent to assume that the proposed monofill will be in place for perpetuity. Nearby residential areas are also assumed to be used in perpetuity, and also that they will be served by on-site wells for water supply. Thus, long-term (i.e. hundreds of years) considerations of the effects of the proposed monofill are important.

Some common contaminants are known to migrate thousands of feet downgradient from source areas. In this area, the sand and gravel aquifer has a generally low potential to attenuate contaminants. Without more detailed studies, detailed predictions of the maximum potential distance that contaminants could flow are difficult to make. Considering all of the uncertainties, however, it would not be unreasonable to consider that all of the wells within a one-mile radius in a down-gradient direction are potentially at risk.

Groundwater is believed to flow towards the southwest and there are numerous wells in that general direction. An important aspect of the proposed monofill is its large size. At approximately 1000 feet wide in a direction perpendicular to the direction of groundwater flow, and considering the normal widening of plumes from their source, it should be expected that if any significant amount of contamination should emanate from this site, it will encompass numerous (i.e probably more than 20) wells within a one-mile radius in a down-gradient direction. Some of these wells are shown on Inset 2, Detail of Figure 2, of Munter (2010). The existing public databases on which these well data are based are generally known to be incomplete and there are likely some wells for which there are no known well records in public databases, and thus there are likely more wells present than are mapped.

As described in more detail below, most of the known wells tap the same aquifer as the aquifer that underlies the proposed monofill site. Thus, there is the potential to contaminate water wells from this facility.

An EPA study documented increases in several constituents downgradient of C & D landfills. Regulatory significance of these increases is based largely on whether specific water quality standards are exceeded, and whether the MCLs are primary or secondary standards. Secondary standards exist primarily for aesthetic, not health-based reasons. Even exceedence of aesthetic standards, however, is expected to adversely affect well owners who may object to any change in their water quality. Such changes can prompt the need for water treatment, additional testing for other health-based contaminants, and create uncertainty over the quality and health-security of their water and potential impacts on themselves, other household residents, and guests who may consume the water.

For some trace contaminants, even the MCL is the subject of evaluation and change, as exemplified by the reduction of the MCL for arsenic in drinking water from 50 micrograms/liter to 10 micrograms/liter since 2001. Thus, when considering long-term water quality concerns, even reliance on current water quality standards as determiners of safety is not necessarily protective.

**Characterize the aquifer at risk – in layman's terms.**

The aquifer at risk is comprised predominantly of sand and gravel with some silt. Tha aquifer extends from hilly regions northwest of Palmer to the Palmer Hay Flats to the south and practically all of the private and public wells in the vicinity use it for water supply. The sand and gravel generally extends from the land surface to bedrock, which occurs at varying depths up to approximately 200 ft in the area. The water table, which is essentially the top of the zone of saturation, occurs at a varying depth from essentially 0 ft at the edges of ponds and lakes up to approximately 100 ft, depending on the topography. This aquifer is also known as an unconfined aquifer. The direction of groundwater flow in the aquifer is generally towards the south and southwest.

All of the water wells, monitoring wells and surface water bodies in the close vicinity of the proposed monofill tap the same aquifer. The silt deposits above and within the aquifer are small and generally are not laterally continuous or thick enough to constitute significant protective layers on the scale of the analysis of the effects of the proposed monofill.

**Review of a June 14, 2013 letter from Central Monofill Services and evaluation of section on "Protection of the Aquifer".**

A key point made in the letter from CMS on aquifer protection is their assertion that there are two aquifers. This assertion appears to stem from non-public analysis and public testimony from Mr. Young of Terrasat on June 3. While the analysis is stated to follow many years of study of the area, the testimony is peculiar because Terrasat's own groundwater study report of August 2012, signed by Mr. Young, makes no mention of this condition.

Terrasat constructed a three dimensional groundwater flow model of the area of the proposed monofill. Terrasat describes the sediment to "consist mostly of sand and gravel with varying amounts of silt and silt lenses". There is no mention of any significant confining layer separating two aquifers.

Terrasat states that "Three hydrologic layers were used to represent the unconfined aquifer in the modeling area". There is no mention of a layered aquifer system with two aquifers separated by a confining layer. The use of three layers to model a single aquifer is a common modeling technique for modeling irregular aquifer boundaries in a single aquifer.

Terrasat also presented a detailed bedrock topographic map that was used to define the base of the single unconfined aquifer.

The model results presented by Terrasat demonstrate that the unconfined aquifer responds as a single hydrogeologic unit that responds to hydraulic stresses imposed upon it, such as the breach of the dike between two of the ponds and a six-ft rise in the water table. This aquifer extends at least from Canoe Lake to the ponds northeast of the monofill site and southward to the Glenn Highway and beyond and includes the proposed monofill site.

Interestingly, the on-site boring logs and all of the recent reports on the site by Terrasat, Brailey, and Munter as contained in the on-line packets are consistent in describing the presence of a single unconfined aquifer above bedrock with a thickness up to approximately 200 ft. The analysis upon which Mr. Young based his testimony is absent from the public record and unavailable for examination. Mr. Young's conclusions, therefore, about the presence of two aquifers are unsubstantiated and should not be relied upon.

While silty zones are present within the aquifer, nowhere have they been demonstrated to be of sufficient thickness or lateral continuity to constitute a confining layer that separates two aquifers. For the purposes of contaminant transport on the scale of the proposed facility and its surroundings, the aquifer should be considered as a single unit that will allow contaminants to migrate horizontally and vertically in response to normal groundwater flow system processes.

While increasing distance from a source provides some protection, wells in the area should not be considered "protected" on the basis of tapping into a different aquifer.

Regarding the assertion that CMS's hydrologist has determined that there are two aquifers at the site and testified accordingly, I found no credible evidence in the written record or in my own analysis of the hydrogeology of the area that this is a reasonable conclusion for the aquifer in the area.

The letter also refers to "our clay/silt liner" as a protective element of the project. This topic is covered in detail above, concluding that no effective liner should be assumed for this proposed development.

In summary, the letter's principal hydrogeologic conclusion that contamination of water in water wells will "never happen" should not be relied upon.

The letter also states that they have the ability to "discover and remediate any contamination" of the aquifer, should it occur. This will be difficult or practically impossible to accomplish. Remediating groundwater contamination is, in general, very difficult and expensive, and in many instances, simply impractical. For example, "pump and treat" systems have been found to be generally not cost-effective. Subsurface reaction barriers are very expensive and difficult to design, construct, and operate and work for only some contaminants. Monitored Natural Attenuation, in which contaminants are allowed to naturally disperse and degrade while being monitored works only if there are no nearby receptors such as wells, streams, or lakes. This may not be appropriate for this site.

Because remediation of groundwater is so difficult, the practical solution that public managers develop at many sites is the provision of public water from a safe source and the abandonment of private wells. This does not solve the problem of seepage of contaminated water to lakes and streams, however, or solve other long-term problems related to ownership and management of contaminated sites.

Remediation efforts commonly start with isolating or removing contamination sources. Removing all of the accumulated waste in the monofill might be impractical. However, constructing a permanent impermeable cap might help isolate the source from percolating water. This would effectively stop all operations at the facility.

Without further clarification from the applicant on how they would remediate the aquifer, and more importantly, how it would get paid for, groundwater remediation should not be regarded as a viable management strategy at this site.

The letter also states that a groundwater monitoring program will protect water wells. This conflicts with the applicant's submittal to ADEC that states "N/A" with regard to the presence of a groundwater monitoring program. In the absence of further information about the program, it is impossible to confirm that it is at all protective of the aquifer or nearby water wells.

In summary, the section of the report about "protection of the aquifer" does not appear to provide any substantive assurance that the aquifer is protected or that groundwater contamination can be detected or remediated should it occur.

Should you have any questions about this report, please call me at 345-0165 or 727-6310.

Sincerely,
**J. A. Munter Consulting, Inc.**

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Alaska Licensed Professional Geologist No. 568

References Cited

Brailey Hydrologic Consultants, 2007, Hydrologic Evaluation of Proposed Dredging Operation, Palmer Gravel Pit, Anchorage Sand and Gravel, Inc., Anchorage, Alaska, 16 p. plus appendix.

J. A. Munter Consulting, Inc. 2010, Potential hydrologic effects of gravel extraction south of Palmer, Alaska, report to Matanuska-Susitna Borough, Palmer, Alaska, April 2010.

Terrasat Inc., 2012, Report of groundwater modeling of the Granite gravel pits and the hydrogeologic effects of gravel extraction on Canoe Lake, Report for Granite Construction company, August 20, 2012.

ICF Incorporated, 1995, Damage Cases: Construction and Demolations Waste Landfills, report for U. S. Environmental Protection Agency, Office of Solid Waste. (draft) found at:
http://www.epa.gov/osw/hazard/generation/sqg/damages/dam-pdf/damage.pdf

Freeze, R. Allan and John A. Cherry, 1979, Groundwater, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.