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To:
Ms. Amy Manzelli, Esq.
BCM Environmental & Land Law, PLLC
3 Maple Street
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18 April 2024

Subject: Review comments on engineering:
Solid Waste Permit Application – GSL Landfill, Dalton and Bethlehem, New Hampshire

Dear Ms. Manzelli:

As per the agreement of service with BCM Environmental & Land Law, PLLC (BCM), I have reviewed the Solid Waste Permit Application for the Granite State Landfill (GSL), proposed to be located in Dalton and Bethlehem, New Hampshire.

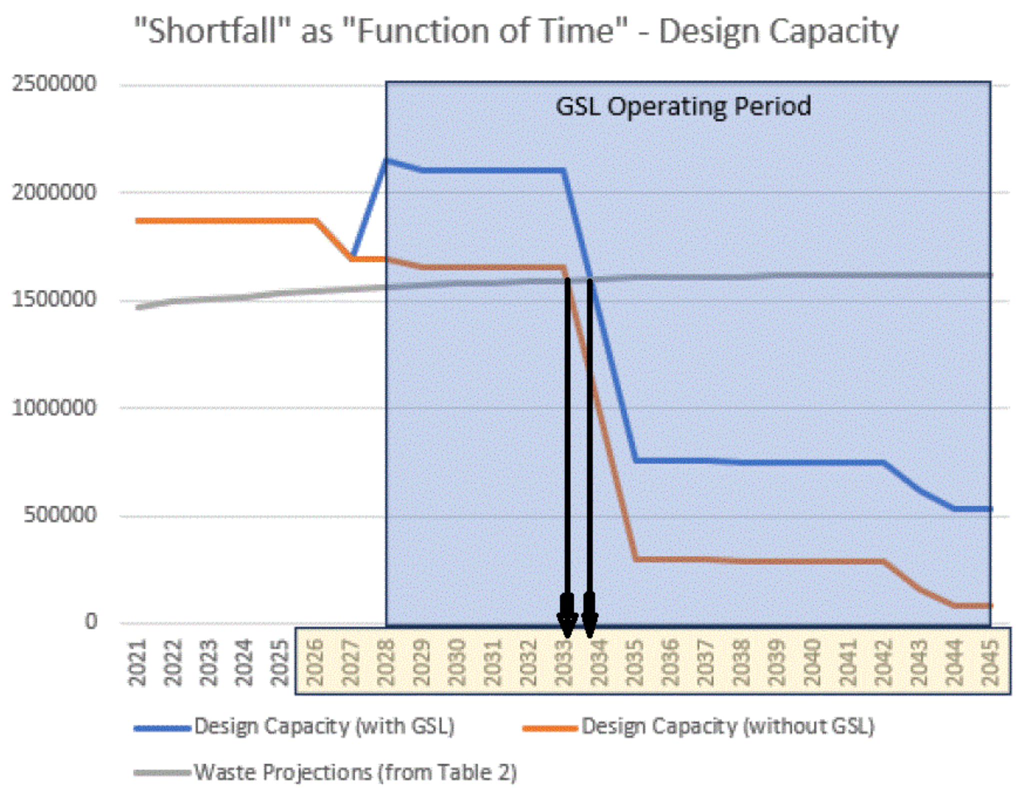
In this letter, I present my comments related to two aspects of the permit application:

1. Review of waste disposal capacity and public benefit claim by the applicant; and
2. Review of the proposed landfill design

1. Waste Disposal Capacity

a. Rate of capacity depletion

The applicant has sought to demonstrate that it satisfies the public benefit requirement needed to justify the granting of a solid waste permit. In Reference 1, the applicant has included a graph showing "Shortfall" in design capacity as a "Function of Time". The figure is reproduced below (with lines added) for the purpose of this discussion.



Planning period highlighted in yellow on x-axis

Figure from Reference 1. (Black lines and arrows added)

In my professional opinion, this graph does not support the premise that permitting GSL will help with the design capacity. When the two plots of design capacity as a function of time are compared (blue line – with GSL and red line – without GSL), there is an addition of capacity between 2028 and 2033, i.e., the blue line is above the red line. However, the capacity decreases precipitously when NCES closes and both lines drop sharply between roughly 2033 and 2035. The rates of drop (i.e., the slopes of the blue and the red lines) between 2033 and 2035 are almost identical.

The gray line represents the waste projection (i.e., generation). When this line is below the red-line or the blue-line, it means that the amount of waste produced or generated is smaller than the design capacity available in the landfills, i.e., there is space to accommodate the waste material.

The cross-over point, when the waste projection (gray) line crosses the capacity line, represents the instant of time when capacity runs out, after which the generation becomes higher than capacity (gray line is above). By inspecting the graphs, one can see that the gray line (waste projection) crosses both the blue line (design capacity with GSL) and the red line (design capacity without GSL) between 2033 and 2034, i.e., within less than a year of each other. That means the availability of GSL would help move the date when waste capacity runs out by *less than one year*. That is to say, without GSL, the capacity would run out at the beginning of 2033 and with GSL it would run out towards the end of 2033 (note the two arrows added in the figure).

As permitting this landfill would only move the date when New Hampshire runs out of waste disposal capacity by less than one year, it calls into question the reasonableness of the argument that permitting this landfill would provide a *substantial* public benefit.

b. Claim of impending crisis due to lack of waste disposal capacity

According to Reference 1 (quoting the Biennial Solid Waste Report prepared by NHDES in November 2022), approximately 47% of the solid waste received at New Hampshire landfills in 2020 originated from out of state. Assuming that net imports remain at 2020 levels over the 20-year planning period, imported waste will consume over 18,276,660 tons of New Hampshire capacity over that period.

Citing the same source, the applicant has reported that the capacity shortfall calculated under RSA 149-M:11 for the planning period will range from 11,145,699 tons at the low end to 26,896,099 tons at the high end, considering only waste material that is generated in New Hampshire.

The applicant has also stated that the actual shortfall will range from 29,422,359 tons at the low end to 45,172,759 tons at the high end when the out-of-state waste (18,276,660 tons) is added to the shortfall. The applicant has claimed that "*a shortfall of such magnitude would create crisis conditions*." According to the applicant, "*[a]ny disposal capacity provided during the planning period mitigates this crisis and promotes the express findings and declarations of the general court.*"

The applicant's claim that there would be "*crisis conditions*" because New Hampshire would not be able to dispose of out-of-state waste at the same rate as it is doing now raises the question if disposing of out-of-state waste at the same rate as it is doing now is truly in the public benefit.

2. Review of the proposed landfill design

a. Use of peak instead of residual strength properties

The applicant has presented the Geotechnical Evaluation and Calculations in Section VI, Attachment VI (3). The interface and internal shear strength properties of soil and geosynthetic materials used in the analyses were all selected from recent projects. The supporting laboratory test results were presented under Supplemental Materials.

Shear strength properties are typically measured in direct shear tests and the results are expressed in the form of a cohesion factor (expressed in units of pressure, in this case pounds per square foot, or psf) and friction angle (expressed in degrees). In most instances, a material, or an interface between two materials, exhibits a relatively high resistance to initial shearing and then, as the shearing continues, the resistance drops. The relatively high value of resistance, which is typically mobilized with a small amount of displacement is termed the "peak" shear strength (reported in the form of a peak cohesion and a peak friction angle). The value of resistance encountered after a relatively large amount of shear displacement is termed "residual" shear strength (sometimes also referred to as "post-peak" shear strength). Residual shear strength is reported in the form of a residual cohesion and a residual friction angle. In almost all cases, the peak values are higher than their respective residual counterparts.

The applicant has used peak shear strength properties in all stability analyses. Because the liner system would consist of several layers of materials (which have different shear strength properties), the shear strength of the material or interface with the lowest strength controls failure and is usually used in the analyses. In the specific case of GSL, the lower bound values of peak cohesion = 302 psf and peak internal friction angle = 24° were used in the stability analyses for the liner interface. The applicant also evaluated the liner interface stability using the internal shear strength of the geosynthetic clay liner (GCL), using the peak strength properties (which are a peak cohesion = 3,100 psf and a peak friction angle = 12°).

The reviewer does not agree with the use of peak shear strength parameters for all the cases and believes it would be more appropriate to use the residual (post-peak) strength when dealing with liners on sloped surfaces. The peak shear strength of geosynthetic interfaces is mobilized at relatively small movements and only the residual strength is available for resisting further movements. The same is true for the internal strength of a GCL.

For example, according to the results of direct shear tests presented by the applicant, the peak shear strength is mobilized at a displacement of approximately 0.5 inches. When displacement exceeds this value, the shear strength rapidly decreases to the residual value. It is possible for such small movements to occur while the liner is installed on sloping surfaces or when waste material is first deposited and compacted in place immediately after the liner on a slope is constructed. For reference, the base of the subject landfill is inclined at a slope of approximately 10% in the cross-section AA' used in the stability analyses by the applicant. It is reasonable to expect that the liner on this sloping base will experience a small downslope movement during deployment and waste filling operation. Thus, the peak shear strength would have already been mobilized, leaving only residual shear strength to resist any further movement.

The two materials with the lowest shear strength values would be (a) the textured geomembrane liner versus the GCL and (b) the internal strength of the GCL. The applicant has cited the peak shear strength properties of the former as the lower bound value to be used in the analyses.

In fact, the residual shear strength of the same interface has significantly lower values and should have been used in the analyses. The residual value of cohesion is 255 psf and friction angle is 12.7°, while the peak value of cohesion is 302 psf and the peak friction angle is 24°. The peak values were used in the analyses. Similarly, the residual value of internal shear strength of the GCL is much smaller than the peak value, which was used in the analyses.

The use of the residual values in stability analyses would significantly reduce the factor of safety. In order to meet the minimum acceptable factor of safety, the landfill configuration would have to be altered, making the slopes flatter and the heights of the landfill lower.

b. Output of slope stability analyses

The applicant has presented only figures for the slope stability analyses in the Supplemental Materials submitted in February 2024. No output files have been provided. Without the output files, it is not possible for the reviewer to know what input parameters were used and what slope configurations were analyzed. The output files from the slope stability analyses for the most critical cases need to be submitted for review.

c. HELP model analyses – not accounting for actual slopes

The HELP model analysis was used to estimate the quantity of leachate generated in the landfill and determine whether the leachate collection and removal system would have sufficient capacity. The data in the HELP model shows that slope of the leachate collection system was entered as 5% in the analyses. However, the bottom slopes in the slope stability analyses (cross sections AA' and BB') are at slopes of approximately 10% and the side slopes are at 3H:1V, i.e., at 33%.

The slopes used in the HELP model analyses should be consistent with the slopes shown in the cross sections. Generally, a steeper slope would result in a higher leachate flow rate, i.e., it is not conservative to use a flatter slope (such as 5%), when the actual slopes are steeper (10% or 33%).

d. Proposed stormwater management system – not considering effects of climate change

The proposed stormwater management system does not explicitly take into account the effects of climate change, such as the occurrence of more intense precipitation events, consistent with the requirement of Env-Sw 314.10(b)(4) to discuss the facility's impact. Without taking climate change effects into account, the landfill is not designed to handle storm events that may occur during its lifetime, and this can have destructive consequences to the community and the environment.

e. Separation between bottom liner and seasonal high groundwater – not considering effects of climate change

The landfill design states that minimum separation between the bottom liner and seasonal high groundwater table is generally 7 ft, whereas it is required to be at least 6 ft as per Env-Sw 804.02(d). However, this separation does not take into account how climate change might affect the seasonal groundwater table in the area. An increase in the groundwater table would reduce the required separation. A separation of less than 6 ft would no longer comply with the regulation and would increase the likelihood of contamination in the groundwater in the event of a leak.

e. Proposed regulation requires 50-year, 24-hour storm

The peak leachate flow rates and infiltration rates were calculated with the use of HELP model analyses for a 25-year, 24-hour storm. However, the proposed regulation Env-Sw 805.09(f) requires 50-year, 24-hour storm. The analyses and any design based on the analyses do not meet the requirements of the proposed regulation.

f. Other potential pathways for leachate migration

There may be other potential pathways in which the landfill (as designed) could pose a threat to the groundwater. For example, the leachate tanks and handling systems are located in an area that is outside the double-lined area and will not provide the same degree of protection in the case of a leak or a spill.

Reference:

1. Standard Permit for Solid Waste Landfill Granite State Landfill Douglas Drive Dalton, NH 03598 NHDES Site #: TBD Project Type: SW-LNDFILL, Volume 6 Public Benefit, Signature, Fee Calculation

Please let me know if you have questions about my comments and/or require further discussions.

Sincerely,

Anirban De, Ph.D., P.E.