STATE OF NEW MEXICO
WATER QUALITY CONTROL COMMISSION

In the Matter of: **PROPOSED AMENDMENTS TO 20.6.6 NMAC (Dairy Rule)**	**No. WQCC 12-09(R)** **and** **No. WQCC 13-08(R)**

Dairy Industry Group for a Clean Environment,
Petitioner

WRITTEN REBUTTAL TESTIMONY OF KATHY J. MARTIN, PE (NM#21522)

My name is Kathy J. Martin, and I am presenting this rebuttal testimony in the New Mexico Water Quality Control Commission (Commission) rule-making hearing case No. WQCC 12-09(R) and WQCC 13-08(R) concerning September 4, 2012 and August 5, 2013 Dairy Industry Group for a Clean Environment (DIGCE) petitions to amend 20.6.6 NMAC, the "Ground Water Protection – Supplemental Permitting Requirements for Dairy Facilities" ("Dairy Rule"). As stated in my written direct testimony in this case, I am testifying as an expert witness on behalf of the Sierra Club Rio Grande Chapter, Amigos Bravos, Lee County Concerned Citizens, Rio Valle Concerned Citizens and Caballo Concerned Citizens.

I. INTRODUCTION

Pursuant to the Commission Hearing Officer's October 3, 2014 Procedural Order, the following is my written rebuttal testimony in response to the October 17, 2014 pre-filed written direct testimony of DIGCE experts Lonny Ashcraft and I. Keith Gordon. My rebuttal testimony follows the various experts' testimony sequence, which in turn is dictated by the sections of the rule each DIGCE expert provided in Direct Testimony.

I am aware that a pending motion from NMED requests that my colleague William C. Olson's testimony be struck in whole or part and he be barred from appearing as an expert witness for the Coalition. In the event that all or part of that motion is granted, having reviewed Mr. Olson's direct and rebuttal testimony and supporting exhibits, and having reviewed the documents comprising his exhibits in the course of the original dairy rule proceedings, I hereby adopt it as my own and incorporate it by reference herein with my testimony as set forth below.

II. REBUTTAL TESTIMONY TO DIGCE'S PRE-FILED DIRECT TESTIMONY

A. LONNY ASHCRAFT TESTIMONY

1. Removing 'solids settling' from definition of impoundment in 20.6.6.7(18).

Mr. Ashcraft claims on page 3 of his Direct Testimony that there are many ways to remove solids from a manure wastewater, such as "settling tanks, settling basins, or settling channels" and thus because of the variety of choices, one should not consider those devices or structures as impoundments. He goes on to say on page 4 of his Direct Testimony that some of those devices or structures are made of concrete and that concrete structures are 'not thought of as impoundments'. Finally, on page 4 he argues that concrete settling basins could be required to have a monitoring well, and that was not the intent of the Commission, so one must remove the solid settling example from the definition of impoundment.

The purpose of supplying a definition section to a Rule is to provide a unique definition to a particular term beyond its typical meaning as found in a dictionary. It is the Commission's discretion in the Definition Section of the Dairy Rule to provide clarity or to elaborate upon a term's meaning in order for the Dairy Rule to be understood. In this instance, the definition of impoundment in the Dairy Rule is inclusive of many types of structures found at dairy facilities and gives examples of possible uses of those structures. It is perfectly reasonable for a structure that is used for solids settling to be included in the definition of an impoundment.

If the purpose is to not require monitoring for solids settling structures, that can be remedied in the section on monitoring well requirements. If the purpose is to eliminate a liner requirement for solids settling structures, that can be remedied in the section on liners. However, by eliminating the term in the definition section serves to categorically make all solids settling structures and devices outside the authority of the regulation regardless of any particular risk to ground water. Finally, concrete-lined impoundments are used in dairies elsewhere in the country, such as Wisconsin and Indiana, especially for sand settling and solid settling purposes. In Wisconsin, the entire wastewater impoundment can be lined with concrete and they have construction standards and leak detection system requirements for them.

The Commission should consider that a structure used to settle solids is a structure that contains manure-laden wastewater for a period of time to allow for separation of solids. That same period of time could allow leakage or seepage of the liquid portion into the subsurface. If the settling method is a basin or channel, there should be liner requirements to minimize or prevent seepage and leakage into the subsurface and the ground water. In addition, there should be requirements to prevent stormwater run-on in order to minimize flooding of the structure during rain events. Further, there should be requirements to prevent over-topping or spillage. There should be requirements to protect the liner from damage by equipment, such as front-end loaders or scraping machines, used to periodically remove the solids from the structure.

It is my professional engineering opinion that solid separating structures should be regulated in the Dairy Rule as impoundments and be required to have liners and other requirements to minimize or prevent contamination of ground water including, but not limited to, minimum construction, maintenance and operation standards.

2. Removing the requirement for discharge to a manure solids separator in 20.6.6.20(F).

On page 6 of Mr. Ashcraft's Direct Testimony he claims that the requirement for a manure solids separator is an arbitrary requirement that encroaches on management's authority. He says that some small dairies don't need separation because they collect their wastewater in tanks and apply it straight to the fields with a honey wagon. Neither reason is based on any scientific evidence that proves there is no need for a manure solids separator.

The need for a manure solids separator is based on sound engineering practices. They are used to remove the solid manure from the liquid wastewater as much as practical so that solids don't accumulate in the storage impoundment. Reducing the amount of solids that accumulate in the storage impoundment means the dairy manager will not have to drain the storage impoundment as often to scrape out those solids or use an agitator to stir up those solids and possibly harm the impoundment liner. Reducing the number of times one has to remove solids from the storage impoundment translates to more storage volume available for liquid wastewater and less opportunity to harm the liner when removing solids from the storage impoundment.

It is my professional engineering opinion that the use of, and requirements for using a manure solids separator is the best engineering practice to protect the storage impoundment and to maximize storage capacity and as such, it should be required for all dairy wastewater systems that use a storage impoundment. The purpose of protecting the storage impoundment liner integrity is to protect the ground water from undue seepage and leakage. Thus, taking away the Commission's authority to require a manure solids separator, and any requirements associated with it, does not protect the ground water from pollution.

3. Removing the requirement for sealed design schematic in 20.6.6.17(C)(5)(b).

Mr. Ashcraft opines that once 20.6.6.20(F) is removed (the requirement to use a manure solids separator), the need for a sealed schematic of said separator is no longer necessary. Since Mr. Ashcraft does not provide any scientific evidence as to why the Commission should not require a manure solid separator, it follows that the regulatory language that requires a sealed design schematic should be retained in the Dairy Rule. Again, the reason for requiring manure solid separators is to reduce the amount of solids that are discharged to the storage impoundment. The direct benefit is to reduce the number of times the dairy has to remove the solids from the storage impoundment and risk damaging the liner. The sealed design schematic of a manure solid separator is the best way a design engineer can demonstrate to the department that the structure will be built in a manner which assures solids removal and the structure is designed to minimize or prevent seepage and spillage and thus protect the ground water from pollution. The term "department" used in this rebuttal follows the meaning and use of that term in the Dairy Rule.

It is my professional engineering opinion that sealed design schematics, whether proposed by the applicant or required by the department, be required for all manure solids separators and submitted with the permit application.

4. Removing the requirement for flow meter specifications in 20.6.6.17(C)(7).

Mr. Ashcraft claims, on page 8 of his Direct Testimony, that the title of this section of the rule does not reflect what is required in the text of the section. His argument is that because the word "specification" is not in the text, it should not be in the title. Using that logic, the word "plan" should not be in the title either, but he failed to mention that as a problem. The text uses the word "documentation" and "information" rather than "plans and specifications".

The Coalition proposes that 20.5.5.17(C)(7) be amended to reflect the title as follows:

(7) **Flow metering plans and specifications.** An applicant or permittee proposing or required to install a flow meter(s) shall submit plans and specifications and other documentation to support the selection of the proposed device as appropriate for the expected flow rate along with a description of the location and information on the installation or construction of each device.

(a) Such plans and specifications and other documentation ~~information~~ shall be submitted to the department with the application for a new, renewed or modified discharge permit.

(b) Such plans and specifications and other documentation ~~information~~ not proposed by the applicant or permittee but required to achieve compliance with the dairy rule shall be submitted to the department within 90 days of the effective date of the discharge permit.

It is my professional engineering opinion that plans and specifications and other documentation is the most appropriate method of conveying information to the department with respect to how the engineer determined the flow meter(s) of choice and how and where the flow meter(s) will be installed in the waste management system.

5. Removing the requirement to sample stormwater impoundments in 20.6.6.24(D).

On page 16 of Mr. Ashcraft's Direct Testimony, he states "that the primary reason to sample stormwater is to determine the nutrient content of the stormwater that will be land applied to the land." He follows by claiming if the stormwater is transferred to the wastewater impoundment, then the nutrient content would be added to the wastewater impoundment and that is the best place to sample for nutrients that will be land applied. Sampling wastewater destined for land application is not the only reason to analyze the stormwater stored in stormwater impoundments.

Rule 20.6.6.25(D) actually requires the stormwater samples to be analyzed for more than just nutrients, specifically "nitrate as nitrogen, total Kjeldahl nitrogen, chloride, total sulfur and total dissolved solids." Nothing in this rule requires that all stormwater collected in stormwater impoundments be immediately transferred to a wastewater impoundment. In fact, stormwater impoundments can be evaporative in nature, thus not requiring transfer or land application. The Commission should consider that stormwater runoff from corrals can transport manure to the stormwater impoundment(s) and not just "clean" rain water.

The Commission should consider that a better reason to sample stormwater in stormwater impoundments is to determine the concentration of nutrients and salts that may be held in that impoundment for a considerable amount of time, such as until the liquid evaporates or when the next land application event occurs. The risk to the environment and the ground water is from leakage and seepage from the stormwater impoundment itself while holding the stormwater. If the concentrations are shown to be minimal, then the department knows that the risk to the ground water is also minimal. However, if the sampling and analysis shows that concentrations are high enough to be of concern, the department and the dairy have the opportunity to rethink the storage of that stormwater and to evaluate the appropriateness of the liner.

It is my professional engineering opinion that sampling and analysis of stormwater held in stormwater impoundments is important to determine the risk of pollution to ground water.

<u>6. Changing the frequency of wastewater sampling and analysis in 20.6.6.25(C).</u>

On page 17 of Mr. Ashcraft's Direct Testimony, he infers once again that the only reason to sample wastewater held in wastewater impoundments is to determine the nutrient content prior to land application. Again, he fails to acknowledge that the better reason to sample wastewater is to determine the concentration of pollutants in the wastewater, and, thus the degree of risk to ground water pollution via leakage and seepage from the impoundment.

Mr. Ashcraft claims that sampling the impoundment is hazardous and costly and thus the frequency that sampling occurs should be limited to once a year or even every other year. He puts forth the idea that the data from sampling is variable and of limited value as compared to annual soil sampling from a nutrient management standpoint. In light of that, I am surprised he didn't recommend that there be no sampling at all.

At some point, we must agree that there are two reasons to sample wastewater stored in impoundments. The first reason is to ascertain the concentrations of a set of pollutants that pose a risk to ground water. The second reason is to establish the amount of nitrogen that can be plugged in to the nutrient management plan to determine appropriate land application rates. We must also agree that although sampling and analysis costs money and may be hazardous, it is still an important and vital part of determining the risk of the wastewater to the ground water either in storage or when land applied.

The reason for sampling quarterly is to determine the concentration of pollutants during different climatic conditions, such as during monsoon season when the wastewater can be diluted with stormwater or during dry months when the wastewater becomes more concentrated due to evaporation and lack of dilution. One should also consider that not all dairies land apply the wastewater and instead rely solely upon evaporation.

Mr. Ashcraft states on page 17 of his Direct Testimony that "alternative methods could be more reliable than taking samples directly from an impoundment." He suggests that sampling from a pipe or sump prior to land application would be more practical. Again, this assumes that the only reason to sample the wastewater is to determine the concentration of nutrients. In this instance, Mr. Ashcraft would like the Commission to agree that sampling prior to land application is timely. Unless the laboratory produces the analytical data immediately, it would arrive after the wastewater had been land applied, thus negating the ability to use the concentrations to determine proper land application rates. However, if the dairy had been performing quarterly analysis, then the dairy would have a much better understanding of the concentration of nutrients in the wastewater and plan accordingly for land application.

The testimony of Mr. Ashcraft does not provide a scientific or statistical analysis to demonstrate that less data on wastewater pollution translates to adequate protection of ground water from that pollution. He is asking the Commission to agree, against common sense, that acquiring one-fourth (annual rather than quarterly) or even one-eighth (biannual rather than quarterly) of the data from sampling wastewater will have no bearing on the ability of the department to protect the ground water. He even suggests that sampling soils would somehow be better than sampling wastewater at all – again assuming that all wastewater is land applied and positing, without explanation or merit, that the amount of nutrients in the soil will tell us whether or not the ground water is contaminated.

It is my professional engineering opinion that quarterly sampling of wastewater in wastewater impoundments is an important and vital component of the department's efforts to understand the risk of impounded wastewater and to use that information to make decisions on how best to protect ground water from pollution while it is stored and when it is land applied.

7. Reducing the frequency of sampling irrigation wells in 20.6.6.25(E).

At the time of submitting this rebuttal testimony, the only observations I would make to the Commission about combining the water samples from more than one irrigation well are (a) the concentration of nitrogen pollution could be reduced by dilution with non-contaminated wells and (b) if nitrogen pollution is detected in the irrigation water the department would not be able to determine which irrigation well was the source of that nitrogen.

8. Removing the requirement to composite six grab samples from evaporation impoundments in 20.6.6.26.

On page 20 of Mr. Ashcraft's Direct Testimony, he once again shows that he either does not acknowledge or cannot imagine that the reason to sample wastewater in impoundments is to determine the concentration of pollutants and to understand the risk of pollution to ground water from leakage and seepage of wastewater from those impoundments. In the case of evaporative impoundments, he claims that since there is no land application, there is no need to sample at all. The fact that Mr. Ashcraft cannot "see the value to sampling data" in this instance should be sufficient grounds to dismiss his entire technical testimony as he does not have an adequate understanding of the risks of pollution to ground water that are associated with stored manure wastewater.

When a dairy chooses to dispose of wastewater by evaporation rather than by land application, they are choosing a method that by its very nature increases the concentration of the pollutants in the wastewater. The purpose of determining the concentration of pollutants is even more important in evaporative impoundments because non-volatile pollutants, such as total dissolved solids (salts) accumulate in the wastewater. Total dissolved solids (salts) are a critical pollutant of ground water and should be monitored regularly and with vigor so that both the department and the dairy can evaluate the risk to ground water and effectiveness of the liner in preventing pollution of ground water.

It is my professional engineering opinion that sampling and analysis of evaporative wastewater impoundments is an important and vital component of the department's efforts to establish risk of pollution to ground water and effectiveness of the liner in preventing the pollution of ground water.

9. Various changes to closure requirements in 20.6.6.30.

Mr. Ashcraft wants to remove the words "within one year of removing livestock from the facility" and states on page 21 of his Direct Testimony that the reason is that "wastewater discharges at a dairy cease when cows are no longer being milked." However, the places where he wants to remove this language are the parts of the rule that deal with stormwater and combined stormwater/wastewater impoundments – impoundments that could receive stormwater even if there are no cows being milked.

This stormwater can include contaminated stormwater runoff from the corral area that still has manure in it even if there are no cows. The rule requires those particular impoundments to be emptied within one year of the removal of all livestock. If there is livestock in the corrals, such as the heifers that Mr. Ashcraft suggests, those heifers would still generate manure in the corral area and any stormwater runoff from the corral area would be considered contaminated stormwater runoff. Thus wastewater discharges in the form of contaminated stormwater runoff do not necessarily stop just because the facility stops milking cows if the facility still has livestock on the premises.

It seems that the real concern expressed by Mr. Ashcraft is that closure of wastewater and stormwater impoundments could impede the sale of the dairy. If that is the concern, then the language should be changed to include an option during closure that would allow impoundments to remain open while a sale is actively being pursued. The question then becomes, how long must the department wait before finally requiring the impoundments to be dismantled? The current Dairy Rule provides a period of one year, which should be enough time to complete a sale. Any longer time frames would put into question the integrity of the liners and the risk of impoundments on properties that are not secure from illegal dumping.

When I worked at the Oklahoma Water Resources Board, I handled closure of surface impoundments on a regular basis. My main concern was the security of an abandoned property with impoundments that could be used by persons looking for an easy place to dump waste, trash, or other deleterious substances. The timing of closure, once a facility is no longer in business, is dependent on the department's ability to assure that proper closure takes place before the financial health of the departing business becomes a problem.

With respect to the wording of "all" versus "additional", I do not think Mr. Ashcraft understands the meaning of that sentence in 20.6.6.30(1)(b). The sentence requires the installation of all monitoring wells to be installed before the closure process is completed. That means a dairy that is in the closure process that has not installed any or all of the required monitoring wells would have to at least install the ones that are required under 20.6.6.23 NMAC prior to "permanent closure". The reason for the monitoring wells is to determine if there is contamination of the ground water. The department needs data from those monitoring wells to determine if abatement is required prior to permanent closure. The reasoning set forth by Mr. Ashcraft that we should assume all wells have been installed does not rise to the standard of scientific merit.

On page 22 of Mr. Ashcraft's Direct Testimony he suggests that the manure in the corrals should not be required to be removed unless the land will no longer be used as a dairy. This reasoning is flawed. The manure in the corrals and other surfaces serves as a constant source for contaminated stormwater runoff. Closure activities are meant to remove the sources of contamination, not let them languish. Even if the dairy was sold and remained a dairy, the new owner should start off with clean corrals and surface areas.

It is my professional engineering opinion that the language regarding closure not be changed by the Commission without careful consideration. Consideration should include the department's ability to direct the facility owner to remove all sources of contamination, insist that monitoring wells be installed, data from those wells be evaluated for ground water contamination, and to assure proper closure in a timely manner. All of these closure activities directly impact the ability of the department to protect ground water from pollution.

III. REBUTTAL TESTIMONY TO DIGCE'S PRE-FILED DIRECT TESTIMONY

A. I. KEITH GORDON TESTIMONY

The main premise behind Mr. Gordon's testimony is that DIGCE wants to remove the requirement for a synthetic liner and replace it with a requirement for a compacted soil liner. Mr. Gordon, PE postulates that plastic liners leak and no one can predict how much, but because leakage from soil liners can be quantified they would be the better choice.

In effect, DIGCE would like to turn back the permitting clock to a time when dairy impoundments were constructed with earthen liners and ground water contamination occurred in 57% of the New Mexico dairies. More specifically, this particular rule change serves to reduce the protectiveness of the Dairy Rule – a rule that was laboriously discussed in stakeholder processes for over a year and that withstood many hours of hearings and the subsequent review and deliberation of the Commission. In respect to those considerable efforts, this Commission must be adamant that DIGCE provide expert testimony that offers new scientific evidence that was not available during the original dairy rule-making process. In this, DIGCE has failed.

The current Dairy Rule liner language in particular was crafted by the Commission and was a compromise between double plastic liners and compacted soil liners. Both NMED and the Coalition argued for technological advancement in liner design to plastic liners. In fact, NMED had already been requiring plastic liners during permit renewal for those dairies that had ground water pollution in excess of state standards. It was DIGCE that argued against tougher liner requirements and that is why the Commission finally compromised to a single plastic liner system rather than a double plastic liner system requirement.

The Coalition has already presented testimony to renew their argument for double plastic liners in this expert's Direct Testimony (**Coalition Exhibit KJM-1**) and incorporates it herein by reference. The following rebuttal testimony begins with a general analysis of the information provided by Mr. Gordon with respect to the standard of "new scientific evidence" and then includes some pointed remarks on inconsistencies and inaccuracies in his direct testimony.

It is important to understand the regulatory history of when and how dairies lined wastewater impoundments in New Mexico. Coalition Expert William Olson has provided a detailed regulatory history of dairy regulations and permitting in New Mexico (**Coalition Exhibit WCO-1**) and his testimony is incorporated herein by reference.

It is my understanding that the evolution of New Mexico dairy impoundment design started with simple excavated impoundments with no liner system. The theory at that time was that any manure that settled in the impoundment would cause a manure seal and reduce seepage. The dairy impoundment design improved over time from manure lined impoundments to the use of a compacted soil liner of minimal thickness. After instances of ground water pollution were found to have occurred at dairies with compacted soil liners, the department stepped up the requirements to plastic liners in the next permit issued. Only those impoundments that were found to be causing contamination or new impoundments were required to install a plastic liner. Under the current Dairy Rule, only those facilities that have ground water contamination are required to install plastic liners in order to minimize or prevent pollution of ground water.

To facilitate the Commission's understanding of earthen liners, I want to explain why soil liners are not the same thing as clay liners. Compacted clay liners are technically different than compacted soil liners because the materials used are classified as clays by particle size and mineral content using standard laboratory tests of particle sieve analysis, Atterburg limits of plasticity, and determination of expected permeability as predicted by soil compaction tests at varying degrees of moisture content. Clay liners should be installed at 95% Proctor density and at optimum moisture content.

Clay liner installation must be field verified by performing compaction tests at regular intervals on all layers, especially along berms and corners. The compaction tests measure the "as-constructed" compaction density and moisture content, which can be compared to the laboratory standard. If the field tests reveal a compaction density and/or moisture content that is not within accepted range of values, that portion of the clay liner must be re-installed until it does meet the compaction and moisture content requirements.

Both soil and clay liners are vulnerable to desiccation or drying out, which causes physical changes to the structure of the liner and leads to erosion, desiccation cracks, and ultimately liner failure. Both soil and clay liners are vulnerable to erosion along the berms at the water line due to wave action and along the entire berm due to stormwater and wind erosion.

1. Did Mr. Gordon provide new scientific evidence that compacted soil liners are superior to plastic liners?

The answer is no, he did not. Mr. Gordon provided two exhibits in his Direct Testimony that contained bibliographic information, namely **Gordon-4** and **Gordon-5**.

The exhibit **Gordon-4** is a 1993 publication by the USEPA written by Dr. David E. Daniels and Robert M. Koerner titled "Quality Assurance and Quality Control for Waste Containment Structures". I hope we can all agree that a document published in 1993 could not contain new scientific evidence dated after the original Dairy Rule process of 2009.

The exhibit **Gordon-5** is a two-page bibliography compiled by Mr. Gordon that contains twenty-seven references. Of the twenty-seven items, only nine of those references are dated after 2009. Of those nine items, two were references to a dairy permit for Las Uvas Dairy and one was a rule citation about variances – none of which are journal articles or publications that would rise to the standard of scientific evidence. The remaining six post-2009 references are all citations for federal rules published in 2011 – three of which are related to municipal landfills and the remaining three are related to hazardous waste management.

It remains to be argued whether a mere citation to federal regulations can be considered 'scientific evidence' for reducing the protective nature of the New Mexico Dairy Rule liner requirements. Mr. Gordon did not provide complete copies of those federal regulations nor did he quote from them in any detail to prove that they would rise to the standard of 'scientific evidence' in these rule-making proceedings.

2. Seepage rates through a compacted soil liner were misrepresented.

On page 9 of Mr. Gordon's Direct Testimony, he states exhibit "**Figure 3 of Gordon-2** illustrates how the 2 ft thick CSL would perform in a typical dairy application; with solids reducing the K_{sat} by at least one order of magnitude (ie., to 1×10^{-8} cm/sec)." The exhibit borrows approximate leakage rates for clay liners from Table 8.3 of exhibit **Gordon-3**. The Table contains a notation that the values for clay liners are based on a "3-ft thick clay liner with a 1×10^{-7} cm/s coefficient of permeability". Mr. Gordon is wrong to use the values for a 3-ft thick clay liner to illustrate the leakage rate for a 2-ft compacted soil liner because liner seepage rates increase with decreasing liner thicknesses.

Mr. Gordon is also wrong to inter-mix terminology of compacted *soil* liners and compacted *clay* liners. The difference between small soil particles and clay particles is a difference in particle shape, where soil particles are round and clay particles are flat and sheet-like. A properly constructed clay liner made with clay minerals will have electro-magnetic properties significantly different than inert soil particles. A visual illustration of clay minerals is similar to a deck of playing cards splayed on a table. A visual illustration of round soil particles is similar to marbles in a jar. In a clay liner, the liquid flow path must follow the flat edges of the clay minerals as the liquid travels down through the liner, whereas the flow path through a liner made of rounded particles is shorter and less tortuous.

My explanation of Darcy's Law uses the term 'seepage' rather than 'leakage '. The term 'seepage' is reserved for the flow of liquid through a saturated liner, whereas the term 'leakage' refers to other flow paths that circumvent saturated flow. Leakage from lined impoundments beyond the expected seepage rates occur for reasons including, but not limited to, damage during installation of the liner, damage that occurs during the operational life of the liner, cracks and fissures, chemical reactions between the liner and the impounded wastewater, and erosion due to wave action, stormwater runoff, or wind damage.

Darcy's Law for seepage rates through saturated liners is based on permeability multiplied times the hydraulic gradient. The hydraulic gradient is the sum of the height of the water plus the thickness of the liner divided by the thickness of the liner as follows:

$Q = k \times (H + t)/t$

Where, Q = seepage rate; k = permeability; H = height of water; t = liner thickness

3-ft liner: $Q = 1 \times 10^{-7}$ *cm/sec (10 ft + 3 ft)/3 ft =* 4.33×10^{-7} *cm/sec*

2-ft liner: $Q = 1 \times 10^{-7}$ *cm/sec (10 ft + 2 ft)/2 ft =* 6×10^{-7} *cm/sec*

The units of seepage can be converted to gallons per acre per day as follows:

1×10^{-7} *cm/sec x (3600 sec/hr) x (24 hr/day) x (1 inch/2.54 cm) x (1 gal/231* in^3*) x (144* in^2/ft^2*) x (43,560* ft^2*/acre) = 92 gallons per acre per day*

Thus, seepage rates can be converted to gallons per acre per day as follows:

3-ft liner: 4.33×10^{-7} *cm/sec x (92 gal/acre/day)/(*1×10^{-7} *cm/sec) = 398 gal/acre/day*

2-ft liner: 6×10^{-7} *cm/sec x (92 gal/acre/day)/(*1×10^{-7} *cm/sec) = 554 gal/acre/day*

The difference between the seepage rate of a 2-ft clay liner and a 3-ft clay liner is 156 gallons per acre per day or 28 percent more leakage from the thinner liner assuming a maximum liquid height of 10 feet. If the maximum height of the liquid is 15 feet, then the seepage rates are calculated as;

3-ft liner: $Q = 1 \times 10^{-7}$ *cm/sec (15 ft + 3 ft)/3 ft =* 6×10^{-7} *cm/sec*

2-ft liner: $Q = 1 \times 10^{-7}$ *cm/sec (15 ft + 2 ft)/2 ft =* 8.5×10^{-7} *cm/sec*

My calculations show that a 3-ft thick liner with maximum liquid height equal to 15 feet has the same estimated seepage rate as a 2-ft thick liner with maximum liquid height of only 10 feet.

3. Seepage rate alone is not a valid performance standard.

Seepage rates are in units of gallons per acre per day. The seepage rate is estimated for a particular thickness of liner and for a maximum height of liquid. The annual volume of seepage is estimated by multiplying the seepage rate by number of surface acres of an impoundment and the number of days per year as follows:

A 300 ft x 300 ft impoundment has a surface area of 2 acres.

2 acre impoundment: 554 gal/acre/day x 2 acres x 365 days/yr = 404,420 gallons/year

Once you have an estimated volume of seepage, one can estimate the mass loading of pollutants using the concentration of each pollutant as provided in a wastewater laboratory analysis. In the case of a dairy wastewater impoundment that has a concentration of total nitrogen of 1000 ppm, the mass loading of nitrogen in the seepage volume is calculated as follows:

(404,420 gallons/yr)/1 million x 1000 ppm x (8.34 lbs/gal) = 3,373 lbs of nitrogen/year

That means every year the impoundment is in operation, it can lose 404,420 gallons of wastewater into the subsurface and that seepage contains 3,373 lbs of nitrogen. Over the course of 20 years of dairy operation, the wastewater impoundment seepage volume is 8.088 million gallons and the mass loading to the subsurface is 67,460 lbs of nitrogen.

These calculations are based on ideal conditions and do not include additional volumes of wastewater flowing into the subsurface due to leakage from failures in the liner system. It should be obvious that the result of using a soil liner is to allow millions of gallons of manure wastewater to enter the subsurface and eventually cause pollution of the ground water. Dairy wastewater contains other pollutants besides nitrogen, including but not limited to chlorides, sulfates, total dissolved solids, and pathogens.

4. <u>Material characteristics can greatly impact value of hydraulic conductivity</u>

On page 7 of Mr. Gordon's direct testimony, he claims "the liner materials would be pre-qualified fine-grained soils meeting the standards enumerated on **Figure 2 of Gordon-2**, and further described in **Gordon-4**." It should be noted that none of the material classifications discussed by Mr. Gordon are proposed by DIGCE to be included in the regulatory language of 20.6.6.17(D). **Figure 2 of Gordon-2** is a PowerPoint slide listing soil classifications including grain size (50% or more passing the #200 sieve) and plasticity (Plasticity Index greater or equal to 15 and Liquid Limit greater than or equal to 30). Mr. Gordon provides testimony for using soil liners because he thinks they will perform based on very specific material specifications, but does not go so far as to require those material specifications in the Rule.

On page 36 of the exhibit titled **Gordon-4**, the relationship between hydraulic conductivity and plasticity index is illustrated in Figure 2.8. The graph shows that in order to regularly achieve permeability less than 1 x 10^{-7} cm/sec, the plasticity index should be greater than 25 or 30. Soils with plasticity index of 15 can have permeability up ten times greater (one order of magnitude greater). If the permeability is five times greater, then the seepage rate from the soil liner will be five times greater. Instead of 554 gallons per acre per day, the seepage rate could be as high as 2,770 gallons per acre per day.

On page 37 of the exhibit titled **Gordon-4**, the relationship between hydraulic conductivity and percent fines is illustrated in Figure 2.9. The graph shows that in order to regularly achieve permeability less than 1 x 10-7 cm/sec, the percent fines should be much greater than 50 percent. In fact, the graph shows that materials with 70% fines still exhibit permeability two to three times greater than 1 x 10^{-7} cm/sec. Instead of 554 gallons per acre per day, the seepage rate could be as high as 1,100 to 1,662 gallons per acre per day.

On page 40 of the exhibit titled Gordon-4, the relationship between hydraulic conductivity and clay content (particle sizes less than 2 microns) is illustrated in Figure 2.11. The graph shows that in order to regularly achieve permeability less than 1×10^{-7} cm/sec, the amount of clay minerals in the material should be at least 40 percent. Materials with clay content of only 20 to 30 percent still exhibit permeability up to five times greater than 1×10^{-7} cm/sec. If the permeability is five times greater, then the seepage rate from the soil liner will be five times greater. Instead of 554 gallons per acre per day, the seepage rate could be as high as 2,770 gallons per acre per day.

5. Flow rate from a compacted liner is not solely a function of permeability and thickness.

On page 6 of Mr. Gordon's Direct Testimony, he states "the flow rate for a compacted soil liner, as shown on **Figure 2 of Gordon-2** is strictly a function of the permeability and the thickness." Mr. Gordon is wrong. As explained earlier in this rebuttal testimony, the flow rate, or seepage rate, is a function of the permeability of the material, the thickness of the liner, *and* the maximum height of wastewater stored in the impoundment. It is for this very reason that performance standards for earthen liners must include maximum values for at least three of the four values in Darcy's Law ($Q = k \times (H + t)/t$).

6. Technical parameters proposed to establish "equivalency" in 20.6.6.17(D)(5).

On page 7 of Mr. Gordon's Direct Testimony, he lists five parameters to be used to determine "equivalency" to a single 60-mil HDPE liner. The names of the parameters are part of the new language proposed by DIGCE and include permeability, resistance to degradation by ultraviolet light, compatibility with the liquids anticipated to be collected in the impoundment, tensile strength, and tear and puncture resistance. Not one of these parameters makes any sense when proposing "equivalency" between a plastic liner and a soil liner.

For example, the permeability of a 60-mil HDPE liner is on the order of 1×10^{-12} cm/sec and when compared to the proposed permeability of the soil liner of 1 x 10-7 cm/sec – the soil liner permeability would be five orders of magnitude greater or 10,000 times more permeable than a plastic liner. Mr. Gordon tries to slip in the term 'leakage rate' as though it is synonymous with permeability. Please refer to my explanation above of Darcy's Law and the difference between permeability and seepage (or leakage rate).

Comparing a soil liner's ability to resist degradation to ultraviolet light is not logical and belies any pretence of proposing viable and scientifically based regulatory language. Even perfectly installed soil liners are vulnerable to erosion, desiccation, and wave action, all of which can cause significant increases in permeability and seepage during the operational life of the liner. All of those problems related to soil liners are not comparable to the problem associated with a plastic liner's ability to withstand ultraviolet light. Liner material like HDPE is recommended for impoundments with exposed berms because it is manufactured with carbon black (hence the black color) that prevents degradation in sunlight. No one would use a plastic liner that was manufactured to degrade under sunlight. However, soils sourced at different dairy facilities all over New Mexico would be variable and could not be controlled by a manufacturing process. The "equivalency" is nothing more than a straw-man argument designed to provide some titillating and useless comparison.

Mr. Gordon explains the choice of comparing the compatibility of wastewater to both soil and plastic liners by saying that neither liner system has a waste/liner compatibility problem. What Mr. Gordon does not discuss is the compatibility of each liner type to withstand the physical restraints of impounding manure wastewater, such as when the impoundment is designed for evaporation. In that case, the soil liner would be a poor choice as compared to

HDPE because soil liner integrity is destroyed when it dries out, but HDPE is not adversely affected.

The last category of 'equivalency' proposed by DIGCE and explained by Mr. Gordon is to compare "tensile strength, and tear and puncture resistance". On page 7 of his Direct Testimony he states "compacted soil is obviously superior to HDPE in tensile strength." It is statements like that from Mr. Gordon that causes me great consternation. Perhaps he will demonstrate for the Commission how a handful of compacted clay can be suspended in the air under tensile forces and not break up and plop to the ground. As an encore performance, he claims compacted soil liners are self-healing with nary a word of explanation of how that happens and what type of permeability he expects to find in "self-healing soil liners".

7. Seepage mechanics from impoundment liners is not the same as for landfill secondary liners.

On page 9 of Mr. Gordon's Direct Testimony he states "USEPA Subtitle D establishes this design as prescriptive secondary liner for MSW landfills, and there is a wealth of data supporting its performance." Municipal solid waste (MSW) landfills can be designed to have a composite liner where the primary liner is HDPE and the secondary liner is compacted soil. Seepage through the liner system is based on a small amount of liquid leachate as the "head" or driving force pushing the liquid through any defects in the plastic liner and thus encountering the secondary liner. The head on the secondary liner is significantly less than that on the primary liner due to mechanics. In addition, at times when the landfill is not generating leachate – there is no seepage at all.

However, the liner system of a wastewater impoundment is exposed to a larger head or depth of liquid and thus a greater driving force pushing liquid through the liner. In the case of a plastic liner, the liquid would only escape through pinholes or a rip or tear. In the case of a soil liner, the liquid is pushed through every single available pore space over 100 percent of the wetted perimeter of the impoundment. As long as there is liquid in a soil-lined impoundment, there is a constant opportunity for seepage and ultimately pollution of ground water.

It is my professional engineering opinion that the Direct Testimony of I. Keith Gordon, PE contains no new scientific evidence (post-2009) that soil liners are as protective as plastic liners with respect to minimizing or preventing seepage from wastewater impoundments.

It is my professional opinion that the Direct Testimony of both Lonny Ashcraft and I. Keith Gordon fails to make any compelling argument, based on new scientific evidence (post-2009), that removing restrictive regulatory language will be as protective as the current Dairy Rule in minimizing or preventing pollution of ground water.

It is my professional engineering opinion that given the inaccuracies I have identified in the Direct Testimony of Lonny Ashcraft and I. Keith Gordon, the Water Quality Control Commission should not rely upon their testimony as a basis to remove or reduce restrictive language in the current Dairy Rule.

This concludes my written, pre-filed testimony serving as rebuttal of the Direct Testimony of DIGCE's experts Lonny Ashcraft and I. Keith Gordon, PE.

This expert witness reserves the opportunity to provide further testimony and supporting exhibits should NMED or DIGCE provide Rebuttal related to my Direct Testimony.

I, Kathy J. Martin, PE (NM#21522), swear that the foregoing is true and correct.

Kathy J. Martin, PE (NM#21522) — Date: November 21, 2014

Seal: KATHY JEAN MARTIN, NEW MEXICO, 21522, PROFESSIONAL ENGINEER — Nov 21, 2014