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For: April 29, 2015

Washington Public Hearing

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Recently, headlines around the state touted the arrest of two individuals purportedly responsible for a heinous murder of a third individual. It was a ghastly crime with witnesses and insurmountable evidence. I will name them X and Y and return to them later.

My name is Lynn Allen. My husband John and I have owned a small excavating business since 1970 and been conventional oil and gas well operators since 1981. We reside in Warren County. We are a very small company and WE are also environmentalists according to Webster's definition: "one who advocates the preservation or improvement of the natural environment especially to control pollution."

Natural resources developed our county from the time of the early settlers and they sustain many of us now. It continues to serve us because we have been good stewards of our resources, much of which is renewable. We would never conduct business in a manner which might jeopardize our beautiful homeland by carelessly abandoning safe environmental practices-with or without regulations. We drink the water, breathe the air, eat food produced from its soil, the fish from its streams and enjoy the recreation within our bountiful forests, waters and scenery. Part of why my family loves our work is because while out on our leases daily we see deer drinking from our streams, bear leading their cubs to berries, and myriad other wildlife with whom we share habitat.

We love Warren County, love our rural home and lifestyle and have been proud Pennsylvanians all our lives, raising two sons who both dream of being able to return home to Warren County. Sadly, opportunities do not readily present themselves due to the devastating economic changes in our county. Basically, with the decline in large industry and the shrinking population, it is difficult for young people to establish homes and to help our county grow. Once our sons completed their post-graduate educations they were recruited and offered good paying jobs elsewhere. So for the time being, they work in other states.

Our oldest son has developed a business plan and a time line so that he and his young family can return to help his father ease into retirement and to take over the family businesses.

However, the regulations proposed in 2013 and 2015 will kill our business and put a screeching halt to those plans. Why would Pennsylvania want to end opportunity for hard working, intelligent and educated young people? We need to ***attract*** *the resources young people offer to help* ***re-build*** *and* ***create*** *new opportunities. These regulations are not just a business killer, not just going to bankrupt small businesses and place thousands of people out of work, they are REGION KILLERS.*

I like to think John and I have been excellent employers and community members contributing to worthy causes with our resources and our time. Basically we are plain vanilla, average, hard-working, law abiding citizens.

We have never:
1) engaged in unlawful activity
2) been arrested or even suspected of criminal behavior
3) and we've never polluted anything

But today, we are **victims** of a crime while simultaneously being incriminated of **committing** unnamed crimes. Return now to the arrested individuals X and Y. They were served a warrant for their arrest at which time the crime for which they were being arrested was clearly stated, an attorney was provided, a trial, judgment and consequences to follow. The point is that X and Y were given due process.

In comparison, the Pennsylvania Department of Environmental Protection has not provided the conventional oil industry our due process. <u>The latest proposal has:</u>

1) Developed regulations so complex we have difficulty understanding. (What I do I understand is that for forty five years my husband has conducted all earth disturbances as "restoration paramount" with proper drainage, no erosion, re-seeding and general back to original state status. We did not need to pay an engineer or refer to a 2 inch set of mandates to tell us how to do that.)
2) The latest proposal offered no alternatives for small business which most conventional operators are and for which the DEP has its own

ombudsman. The DEP website states "Small business is the back- bone of Pennsylvania," yet callously disregarded the financial impact on small business by not developing an accurate financial analysis of the costs the new regs will impose.

3) The latest proposal ignored the bi-furcation law set forth by the PA Senate and House inn 2014.
4) ... added regulation to already existing regulations as if more requirements would solve whatever problem they think exists <u>without offering proof that a problem exists.</u>
5) It once again proposed to impose regulations on conventional well operators that do not even pertain to operating shallow wells.

I taught school for ten years. When I made an assignment for an essay to my students I did not place the same restrictions on my eighth grade class as my seniors. My students expected their grade to be comparable to their efforts. I would never punish the entire class because one of them failed the assignment. If I had handed back essays with simply an indiscriminate grade in red ink, no comments or no explanation- such as the new regulations have done to the conventional well business, the students, their parents and my principal would have been in a righteous uproar. This is my uproar. And I intend to roar all the way into the governor's ears.

Where is the integrity of the Department?

Where is the common sense?

Where is <u>our</u> due process?

Comments on the changes to Chapter 78 of the Pennsylvania Oil and Gas drilling Regulations

Thank you for taking the time to listen to my comments on the changes to the gas drilling regulations.

§78a.15. (f) (1) lists the situations under which public resource agencies should be notified "if the LIMIT OF DISTURBANCE of the well SITE is located" within 200 feet of a publically owned park, forest, gameland, or wildlife area, State or National scenic river, National natural landmark, historical or archeological site listed on the Federal or State list of historic places, or within 200 feet of common areas on a school's property or playground.

The DEP should require notification and **not permit** a well pad disturbance area to be within 1000 feet of the public recreation or historical properties listed, and should not allow a well pad or any structures associated with it within a mile of a school property, nursing home, or hospital, public or private. The citizens have a right to use the recreation facilities that their taxes have paid for without the disturbance and possible pollution that is caused by the construction or operation of a well. In addition, populations that are prone to health risks should not be subjected to the noise and possible pollution from the drilling and operation of a well.

§78a.56 (a) says the operator shall collect the brine and other fluids produced during operation[, service and plugging] of the well in a tank[, pit] or a series of [pits or] tanks, or other device approved by the Department for subsequent disposal or reuse.

The DEP should prohibit operators from using **any** open-air pits and tanks, regardless of size or location, for storage and treatment of regulated wastes, including wastewater, drill cuttings, and substances (like gels and cement) that return to the surface after fracking. Waste should be stored and treated only in closed, aboveground systems. Tanks used for the storage of waste should be completely enclosed to reduce the possibility that polluting spills and emissions will occur, and to keep wildlife from being poisoned by drinking from contaminated water and contact with contaminated soil.

Sections that specify restoration of vegetative material such as § 78a.61. (a) (8) should specify that the vegetative cover consist of plants native to the local area rather than invasive non-native plants that would push out established native colonies, and which would not provide the optimal environment to sustain the local animal and insect communities.

§78a.41. (d) states "THE OPERATOR SHALL PERFORM REGULAR, FREQUENT AND COMPREHENSIVE SITE INSPECTIONS TO EVALUATE THE EFFECTIVENESS OF ANY NOISE MITIGATION MEASURES." What incentive does the operator have to accurately evaluate the effectiveness of noise mitigation? ~~We~~ MY FAMILY lives about a thousand feet from an active MARCELLUS well pad. They've been drilling at the pad for the last 2 months. The noise has been loud, even with the windows all closed. You can feel vibrations when you put your hand on the counter tops. Have you even been on a cruise ship? When you go to bed, you feel the throbbing of the engines. That's what it's been like sleeping in our house during the drilling. As a common courtesy, operators should be required to notify residents when they are preparing to drill and the length of time that the drilling will occur. They are bringing a noisy industry into an area where people live. If they would at least apologize for disturbing the residents and acknowledge that the residents are not living in an industrial area by choice, the residents might be willing to put up with the ~~noise~~ inconvenience.

Transparency and Access to Information

The DEP proposes to require oil and gas operators to file permit applications and required reports electronically. This change would improve data collection, efficiency, and enforcement, which is laudable. DEP should also make sure that all electronic filings and reports submitted by operators are also available to the public on DEP's website on the same day they are deemed complete by DEP. Easy and timely access to information by the public is necessary to ensure agency transparency and operator accountability.

Comments on Separation of Conventional and Unconventional Well Regulations

The DEP should end the use of all open-air production pits for the storage of waste and immediate conversion to closed tanks. DEP is proposing to continue to allow conventional operators to store their waste in pits and to bury waste at well sites. Many spills, leaks, and other problems involving conventional pits have occurred statewide. If the waste is potentially toxic and harmful to water, air, soil, and health, the type of well it came from shouldn't determine how it's managed and where it ends up.

All well operators should be required to develop water management plans that specify the source and volume of the water used in site construction, operation, and restoration. All gas development requires large volumes of water and withdrawals can harm streams, rivers, and aquifers. There is no reason to exempt conventional drillers from planning and documenting their water use.

The DEP should prohibit the road-spreading of brine from conventional wells. Brine contains chemicals, hydrocarbons, and salts regardless of the type of well it comes from. The DEP has set limits on contaminant levels in the brine, but has not provided scientific evidence that road-spreading is safe for water, vegetation, and wildlife—especially over large areas for prolonged periods of time.

Comments submitted by
Mary Ann Pike
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Carolyn Rottman
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Date: Wednesday, April 29, 2015
Location of Presentation: Washington and Jefferson College, Rossin Campus Center – Allen Ballroom,60 S. Lincoln St., Washington, PA 15301

I represent a third generation oil and gas producing family with over fifty years of experience.

Anyone in this business is very hard working, pays taxes, and participates in the local community. We live where we work. My family hunts and fishes near our wells and on our property. Northwestern Pennsylvania, where most of us live and work offers beautiful scenery, lots of flora and fauna, and clean streams.

The small producers and drillers of Northern Pennsylvania supply two refineries, Ergon and American with good Pennsylvanian Crude, which is wax based not tar based like the oil produced in the west to make black top. The by-products of **Penn Grade crude** are used in skin softeners, medications, and paraffin candles.

Most who operate shallow oil wells are unable to afford to comply with Chapter 78 regulations. I had recently been given a figure of $100,000 for just one tank battery that is required by the regulations. Small oil and gas producers are not multimillion dollar companies. They have shallow and legacy wells, some one-hundred years old.

Please do not kill the small oil and gas producers in Pennsylvania with impossible to follow regulations. We are your neighbors and we support our local communities. **Do not allow my family get shuffled under by the pretense of modern life!!!**

Celia Janosik
305 Hoenig Rd.,
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April 29, 2015

DEP Regulation changes to Chapter 78 Oil & Gas

Thank you for allowing me to speak this evening. My name is Celia Janosik and I live in Economy Borough, Beaver County. I have leases up against my property, I live in a narrow valley with a clean stream and very good well water at the present time.

As a Mother and grandmother, the health and wellbeing of children and the unborn is my priority as they do not have a vote.

I thank DEP for recognizing the fact that set backs from actual wells are insufficient but I am sorry to say that 200' from the well pad to a school is not an improvement but irresponsible. We need 1 mile setbacks for oil & gas wells, waste storage facilities and any other infrastructure from the property boundary of any school property.
The one mile setback still seems insufficient if you read a gas driller's prospectus.

Range Resources 2013 Prospectus, page 26, reads:

Natural gas, NGLs and oil operations are subject to many risks, including well blowouts, craterings, explosions, uncontrollable flows of oil, gas or well fluids, pipe or cement failures, pipeline ruptures or spills, vandalism, pollution, releases of toxic gases, adverse weather conditions or natural disasters, and other environmental hazards and risks. If any of these hazards occur, we, Range Resources, could sustain substantial loses as a result of ....injury or loss of life.

Too many lives have been ruined by the oil & gas industry. The workers who clean the equipment and people who live within half a mile down wind of any drilling activity face bad health, loss of water, loss of their property value and the loss of jobs. Pets and livestock have died and who knows how many children will be affected long term. It will be hard to prove but we all know in our hearts that living with this heavy industry is bad for us all and don't forget the gorilla in the room. Climate Change.

Thank you

From Range Resources Annual Report 2013 Risks

Our business is subject to operating hazards that could result in substantial losses or liabilities that may not be fully covered under our insurance policies

Natural gas, NGLs and oil operations are subject to many risks, including well blowouts, craterings, explosions, uncontrollable flows of oil, natural gas or well fluids, fires, pipe or cement failures, pipeline ruptures or spills, vandalism, pollution, releases of toxic gases, adverse weather conditions or natural disasters, and other environmental hazards and risks. If any of these hazards occur, we could sustain substantial losses as a result of:

- injury or loss of life;
- severe damage to or destruction of property, natural resources and equipment;
- pollution or other environmental damage;
- investigatory and cleanup responsibilities;
- regulatory investigations and penalties or lawsuits;
- suspension of operations; and
- repairs to resume operations.

We maintain insurance against many, but not all, potential losses or liabilities arising from our operations in accordance with what we believe are customary industry practices and in amounts and at costs that we believe to be prudent and commercially practicable. Our insurance includes deductibles that must be met prior to recovery, as well as sub-limits and/or self-insurance. Additionally, our insurance is subject to exclusions and limitations. Our insurance does not cover every potential risk associated with our operations, including the potential loss of significant revenues. We can provide no assurance that our coverage will adequately protect us against liability from all potential consequences, damages and losses.

We currently have insurance policies covering our operations that include coverage for general liability, excess liability, physical damage to our oil and gas properties, operational control of wells, oil pollution, third-party liability, workers' compensation and employers liability and other coverages. Consistent with insurance coverage generally available to the industry, our insurance policies provide limited coverage for losses or liabilities relating to pollution, with coverage for sudden and accidental occurrences. For example, we maintain operator's extra expense coverage provided by third-party insurers for obligations, expenses or claims that we may incur from a sudden incident that results in negative environmental effects, including obligations, expenses or claims related to seepage and pollution, cleanup and containment, evacuation expenses and control of the well (subject to policy terms and conditions). In the specific event of a well blowout or out-of-control well resulting in negative environmental effects, such operator's extra expense coverage would be our primary source of coverage, with the general liability and excess liability coverage referenced above also providing certain coverage.

In the event we make a claim under our insurance policies, we will be subject to the credit risk of the insurers. Volatility and disruption in the financial and credit markets may adversely affect the credit quality of our insurers and impact their ability to pay claims.

Further, we may elect not to obtain insurance if we believe that the cost of available insurance is excessive relative to the risks presented. Some forms of insurance may become unavailable in the future or unavailable on terms that we believe are economically acceptable. No assurance can be given that we will be able to maintain insurance in the future at rates that we consider reasonable, and we may elect to maintain minimal or no insurance coverage. If we incur substantial liability from a significant event and the damages are not covered by insurance or are in excess of policy limits, then we would have lower revenues and funds available to us for our operations, that could, in turn, have a material adverse affect on our business, financial condition and results of operations.

Additionally, we rely to a large extent on facilities owned and operated by third parties, and damage to or destruction of those third-party facilities could affect our ability to process, transport and sell our production. To a limited extent, we maintain business interruption insurance related to a third party processing plant in Pennsylvania where we are insured for potential losses from the interruption of production caused by loss of or damage to the processing plant.

A change in the jurisdictional characterization of some of our assets by federal, state or local regulatory agencies or a change in policy by those agencies may result in increased regulation of our assets, which may cause our revenues to decline and operating expenses to increase

Section 1(b) of the NGA exempts natural gas gathering facilities from regulation by the FERC as a natural gas company under the NGA. We believe that the natural gas pipelines in our gathering systems meet the traditional tests the FERC has used to establish a pipeline's status as a gatherer not subject to regulation as a natural gas company. However, the distinction between the FERC-

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Ambridge, PA 15003

Oil Yield and Uranium Content of Black Shales

By VERNON E. SWANSON

URANIUM IN CARBONACEOUS ROCKS

GEOLOGICAL SURVEY PROFESSIONAL PAPER 356-A

This report concerns work done on behalf of the U.S. Atomic Energy Commission and is published with the permission of the Commission

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UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1960

Google: Uranium Content of Black Shales

UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

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April 29, 2015

Good evening. First off, I want to thank the DEP for coming to the shalefields and hearing community members and my comments today. My name is Eva Westheimer and I live in southwestern Pennsylvania.

The whole nation, no, the whole world, is looking to Pennsylvania-- and not for a good reason. New York, Germany, Maryland, Denmark, and so many more places have looked at Pennsylvania, seen the impacts from unconventional shale gas development, and decided not to subject their residents, land, and our climate to the health and environmental impacts of this dangerous industry.

We must end unconventional shale gas development, more commonly known as fracking, now. It is the Department of Environmental Protection's responsibility to use the precautionary principle, meaning that if the proposed activity from the Drilling Industry has any unknown impacts to the environment or human health, the activity should not be permitted until those impacts are clearly understood.

I appreciate the thorough process for revising Chapter 78 regulations, and expect this much, if not more thoroughness when the State permits each well site. The current permitting process for well sites is a joke. The DEP literally rubber-stamps shale gas well permits. With a permit application process that is less in-depth than a 5th grade science fair project, major drilling industries are tearing our environment and communities apart.

To address impacts that community members currently experience, and with the knowledge that fracking won't end through this round of Chapter 78 revisions, the DEP must make these following revisions to the Chapter 78 regulations to protect our environment, human health, and due process:

1. A full and in-depth process of public participation in the permitting process for oil and gas surface infrastructure. The shale gas industry should not receive the special treatment that it currently does. As with other extractive industries, within the State there should be a full public notice, comment, and public hearing period. All concerned people, not just those within 1,000 feet of the proposed site, have the right to express their opinions on the health and welfare of their community.
2. There must be at least a one-mile setback of all shale gas infrastructure of from school property. Young people are particularly susceptible to the health impacts from air pollution that accompanies shale gas development.
3. Shale gas operators should be prohibited from using open pits (we know that they leak) for storage of contaminants.
4. Drillers must be required to check for orphaned and abandoned wells near their drilling pads and paths. In addition the DEP must conduct cumulative impact studies on the

impacts of drilling and mining in the same locations. Thus far, the DEP has allowed for these two industries to extract in the same locations with no regard or knowledge of the full impact of these two industries operating literally on top of each other.

5. Drilling Companies must restore potable, clean water to those whose water supplies have been affected by drilling.
6. And lastly, the DEP must implement noise controls to protect the quality of life of people living near well pads.

These are just a few, of the many changes that need to be made to protect the environmental and human health. Ultimately, like I said before, the DEP and the Commonwealth must protect environmental and human health before corporate profits. I believe in the creativity of those living within the Commonwealth. I know that we have the ability to create an economy and power source not based on the destruction of our communities, but based on the creativity and power of each and every person within our community. Again, thank you for hearing my comments and recommendations this evening.

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Re: Comments of Range Resources- Appalachia, LLC on Proposed Amendments to 25 Pa. Code 78a

To Whom It May Concern:

Range Resources-Appalachia, LLC ("Range Resources") appreciates the opportunity to comment on the proposed amendments to 25 Pa. Code §§ 78a.1 -78a.404 ("Chapter 78a") published in the Pennsylvania Bulletin on December 14, 2013 and April 4, 2015 that seek to ensure that oil and gas operators employ effective measures that prevent pollution during surface activities, while allowing flexibility for the optimal development of the Commonwealth's natural resources.

Range Resources is a leading independent operator with a leasehold position of over one million acres across western and north central Pennsylvania. Range Resources strives to abide by all federal, state, and local laws and regulations within all of its operating areas. Whether Range Resources is constructing a new well site, operating an existing well site, managing water resources, or working with one of its landowner partners to restore a field for future landowner use, we're committed to conducting business safely and in a socially and environmentally responsible manner. Thus, Range Resources shares the common goal of the Department of Environmental Protection ("DEP") to focus on performance over process.

As Environmental Compliance Manager, I implement Chapter 78a on a daily basis: advising a team of innovative and attentive Pennsylvanians on how to put this two-part goal into action. We, along with the DEP Oil and Gas Inspectors in the field, have to report with confidence to both of our respective management teams that we have assured compliance. The proposed amendments contain some provisions with language that is unclear, vague, and ripe for misinterpretation. On behalf of those of us that operate on the front lines, I ask that you please consider the following comments to support us in upholding our shared goal: preventing pollution while allowing for the optimal development of a natural resource. In so doing, you are providing necessary guideposts for preventing pollution that allow Pennsylvania landowners and employees of both the DEP and operating companies to prosper here in the Commonwealth we call home.

General Comments

A. Opportunity to Clarify Terms Throughout Chapter 78 to Create an Effective Compliance Tool

In general, Range Resources asks that the DEP clarify and streamline its use of terms throughout Chapter 78a to ensure uniformity of interpretation between the DEP and the regulated community. This is emphasized when the terms describe obligations for permit applications that relate back to the direction of Act 13 Section 3215(e) (related to well permit conditions for public resources). For example, in § 78a.15(d), the DEP proposes that operators consult PNDI regarding the presence of a federal or state threatened or endangered species where a well site or access road is proposed. It then states that the operator must "make a demonstration as to how an impact will be avoided or minimized and mitigated . . . to the satisfaction of the applicable Public Resource Agency." This language should be further clarified as to set reasonable expectations. Range Resources, therefore, proposes that the DEP expressly limit this determination to be made by one agency, the DEP, and define clearly what type of impacts trigger this requirement and what would constitute a sufficient demonstration of avoidance, minimization, or mitigation. Such clarification will help to assure uniform consultation between the DEP and operators throughout the various DEP Regions.

B. Need to Consider Landowner Rights and Contractual Obligations

In general, Chapter 78a should be amended to consider the ongoing relationship between the operator and landowner and the contractual agreements to perform or not perform certain activities on a landowner's property. The relationships between operators and private landowners are governed by the terms of lease, easement, and right-of-way agreements that are negotiated between the private parties. Range Resources wishes to point out that some of the proposed requirements do not appear to accommodate such contractual constraints. For example, without the right to enter a landowner's property, an operator cannot carry out the requirements to visually monitor an abandoned or orphaned well as required by the proposed § 78a.73(c). Similarly, a landowner may not want an operator to restore his or her land to approximate original conditions or apply 70% perennial vegetative cover when final restoration is occurring after decades of production and the private landowner's needs may change– often there will be a different landowner entirely. However, the proposed §78a.65 does not appear to provide a flexible path forward for the landowner on how he or she wishes to use the private property.

Specific Comments

1. 78a.1: Opportunity to Clarify Proposed Definitions

Gathering Pipeline: To the extent that the DEP must use the term "gathering pipelines" throughout Chapter 78a, its definition should be replaced and, therefore, made consistent with the PHMSA definition to ensure alignment with other regulating agencies at the federal and state levels. "Gathering line" is defined by PHMSA in 49 C.F.R. § 192.3 as "a pipeline that transports gas from a current production facility to a transmission line or main." Pipeline terms get used interchangeably in common conversation, creating confusion and ambiguity. Thus, it is important to clearly and uniformly define the various types of pipelines in the regulations.

Mine Influenced Water: The proposed definition appears to include all waters impaired by mine drainage. Given this breadth, the definition would include seemingly all surface waters throughout the Commonwealth, including sections of major rivers, such as the Allegheny, Monongahela, Youghiogheny and West Branch of the Susquehanna– some of which are widely used for public water supplies. The definition seems overly broad and does not provide any guidance. Storage and use of such a broad universe of waters should not be subject to the special approval requirements of § 78a.59b(h) for storing such water in a freshwater impoundment. To allow for the beneficial reuse of waters previously impacted by acid mine drainage, Range Resources recommends narrowing the definition to state: "Water contained in a mine pool or a surface discharge of water caused by mining activities that pollutes, or may create a threat of pollution to, waters of the Commonwealth."

Other Critical Communities: Range Resources appreciates the DEP taking steps to further clarify the terms used in § 78a.15, including § 78a.15(f)(iv). Though strides have been made, it appears that further clarification remains necessary. In maintaining the language from Section 205(c) of the Oil and Gas Act of 1984 ("Act 223") in the enacted Act 13, which expressly included the term "critical communities," it does not seem likely or consistent with what the Pennsylvania Legislature intended for this language to be expanded to include "plant and animal species that are <u>not</u> listed as threatened or endangered." Range Resources is concerned that this language in the proposed definition does not lead to an objective definition from which to garner a meaning for the limitations of this definition and, therefore, does not allow for the added definition to be used as an effective compliance tool. The regulated community and the DEP permit reviewers are left with substantial questions as to how to manage this term as it relates to permit conditions. Range Resources asks that the definition be reworked to include an enumerated list of what is included under the scope of the term. It is recommended that the list be limited to those critical communities that are identified after agency review and accessible for planning via the PNDI tool as to create an objective, manageable standard.

2. *78a.15(f): Avoid Potential Confusion from Ambiguous Terms and Accommodate Accelerated Permit Needs*

The provision currently states that if a proposed well site may impact a public resource, the operator must notify the Public Resource Agency no less than 30 days prior to submitting its permit application to the DEP, and that the DEP, based on its determination that a "probable harmful impact," may include well permit conditions to avoid or mitigate those impacts. This language is of critical concern for the regulated community. This language provides no guidance on how the DEP will define "probable harmful impact" and, given the subjective nature of this narrative standard, the proposed language will likely result in unintentionally creating inconsistent enforcement throughout the DEP regions and inconsistent interpretations among operators. This language makes implementing this provision in an effective and responsible manner difficult at best. We are hopeful that the DEP will work with industry, citizens, and the Public Resource Agencies to create a set of defined steps for managing this new process in a manner that meets the shared goal of balancing the prevention of potential environmental harm and optimizing development of Pennsylvania's natural resources.

Further, the proposed provision does not take into account the need for an accelerated permit, leaving §78a.16 essentially superfluous. That provision states: "[I]n cases of hardship, an operator may request an accelerated review of a well permit application." If the proposed unconventional well for which an operator was seeking a permit was near or on a public resource, the new provision would appear to preclude the operator from being able to request an accelerated permit review. This only further highlights the uncertainty in process management presented by the proposed 78a.15(f). Waiting the additional days to notify the Public Resource Agencies added with allowing sufficient time for response from the DEP, and the operator on the Public Resource Agency's comments (without any timeline for coming to a definitive resolve on ambiguous mitigation plan standards) is cumbersome and unnecessary. Range Resources asks the DEP to revise the proposed language to include a practical method for addressing accelerated permits, for defining what types of avoidance or minimization of harm, and for establishing an affirmative response standard and timeline for when responses are due back from the DEP.

3. *78a.41 Need to Clarify the Compliance Tools to Implement Noise Mitigation*

As currently written, the proposed §78a.41 states that operators must implement a "site specific noise mitigation plan to minimize noise during drilling . . ." It further provides the DEP discretion to suspend operations should the DEP determine that the plan is inadequate to minimize noise. The phrase "minimize noise" is narrative and does not act as an effective compliance tool. Noise mitigation, by definition, is the action of reducing the intensity of noise. In order for a mitigation plan to be effective in minimizing noise, there must be a mitigation objective (*i.e.*, an established limit on intensity permitted).

Range Resources recommends that the DEP work with industry to establish such a uniform limitation and that the mitigation plan only be necessary if sounds in excess of the established limit are present. Results from a sound impact assessment should be used preliminarily to determine whether the proposed operations will exceed the established sound limit. A plan to mitigate sounds which exceed the established limit should be prepared and implemented. Range Resources welcomes the opportunity to work with the DEP to perform the necessary further analysis on this issue. Given that this language was added to the April 4, 2015 publication of the amendments, it is Range Resource's opinion that the public has not had sufficient time and opportunity to address the details of this significant new area of regulation.

4. *78a.52a: Clarify a Set List of Sources to Consult to Identify Abandoned and Orphaned Wells*

Before promulgating a rule that utilizes such a broad scope of review, Range Resources asks that the DEP make all available data easily accessible to the industry from one comprehensive source or that the DEP create a concrete list of sources to be consulted to establish the standard required for identifying abandoned and orphaned wells. Without such a comprehensive source of data on orphaned and abandoned wells, assuring a thorough pre-hydraulic fracturing review on a well-by-well basis will be very difficult for the DEP and the regulated community. Operators, including Range Resources, do their best to obtain all information regarding potential orphaned and abandoned wells in the vicinity of a planned unconventional well. However, operators remain without a comprehensive source of best available data from the Commonwealth that would aid in the pre-hydraulic fracturing review.

Range Resources encourages prompt digitization and accessibility of identification resources prior to the implementation of Chapter 78. If a comprehensive source cannot be established by the DEP, Range Resources asks that the DEP consider removing terms such as "other available well databases" and "historical sources of information such as . . ." Both of these phrases are arbitrary depending on the well or operator at issue; thus, making the successful development and implementation of this project difficult. Identifying abandoned and orphaned wells before hydraulic fracturing is good standard practice; however, the rule as currently proposed does not provide operators with enough clarity and flexibility to properly identify and plan operations where such abandoned and orphaned wells may be present.

5. *78a.69(d)(4): Specify What Constitutes Additional Requirements for a Water Management Plan*

This section currently allows the DEP to establish additional requirements as necessary to comply with the laws of the Commonwealth. A regulation is the best mechanism for an agency to document the requirements for implementing Act 13 and for codifying the DEP's policy on what is required. Given the very nature of a water management plan (*i.e.*, forward planning and transparency), Range Resources asks that the DEP remove 78a.69(d)(4) and add any specific plan requirements to the provision itself.

6. *78a.73: Clarify Requirements by Deleting or Defining Ambiguous Language and Address Significant Research Indicating the Depth of Existing Wells within a Given Area of Review*

The proposed subsection does not address possible issues of operator inaccessibility to the abandoned and orphaned wells. Proposed subsections (c) and (d) require operators to physically inspect orphaned and abandoned wells identified under proposed § 78a.52a during hydraulic fracturing activities that likely penetrate a formation intended to be stimulated during hydraulic fracturing. However, access may be denied to the property on which abandoned and orphaned wells are located– making it impossible for operators to comply with the provision. Range Resources asks the DEP to rewrite this section to address an alternative for operators when surface access is not achievable.

Further, § 78a.73(c) proposes to require operators to notify the Department of "any changes" to those wells, to "take action to prevent pollution of waters of the Commonwealth or discharges to the surface," and to "visually monitor" orphaned and abandoned wells during stimulation activities. These phrases are ambiguous. Without specification as to what constitutes a "change" and appropriate "action" to "prevent," and to "visually monitor" in terms of scope and timing, Range Resources is concerned that the proposal will likely result in the unintended consequence of further causing unreasonable burdens and distracting from the shared objective of the DEP and the regulated community of mitigating impacts from the existing landscape of oil and gas wells in Pennsylvania.

Lastly, § 78a.73(c) proposes to require operators to presume that all wells with an unknown true vertical depth within a given area of review be presumed to penetrate within 1,500 feet of the formation intended to be stimulated. Range Resources requests that the presumption language be removed from this section, and it be rewritten to state: "Orphaned and abandoned wells identified as part of an area of review survey conducted under § 78a.52a (relating to area of review) that likely penetrate within 1,500 feet measured vertically of a formation intended to be stimulated . . ."

Range Resources requests this amendment because there are numerous published reports and other private records of such early drilling that describe technologies employed and depths drilled of wells in the commercially developed fields over time. Many of these reports were compiled by the PA Geological Survey and US Geological Survey that worked with the oil and gas operators at various points in time. These reports confirm that early exploration and field development was conducted at depths generally less than 3,000 feet, with very few exceptions. The first significant "deep" drilling in Pennsylvania occurred between 1930-1950, targeting the Oriskany sandstone, located just beneath the Marcellus Shale. For example, there are numerous detailed reports that document this early deep drilling in Tioga, Potter, and surrounding counties. The PA Geologic Survey, the agency that compiled many of these deep drilling reports, constructed a database of deep well records that is quite complete. That database could be relied upon and given sufficient consideration in weighing the need for the presumption language within this provision.

I appreciate your consideration of my comments on behalf of Range Resources. Please note that Range Resources will be submitting its official comprehensive comment to the EQB by the May 19, 2015 deadline.

Sincerely,

Laura Frano, Esq.

Laura Frano, Esq.
Manager of Environmental Compliance

Washington
4-29-15

My name is Jane Worthington, I live at 135 Main Street, Hickory PA, Mt. Pleasant Twp., Washington County, Fort Cherry School District, Home of the Ranger, aka Home of the Dangers!

Although the proposals in chapter 78 and 78a are a great starting point, they do not go far enough to address issues involving a vulnerable portion of our citizens, our children those who have no environmental voice of their own.

Currently Fort Cherry Campus had 2 Fully operational well pads in the approximately 1/2 mile zone from it's property. Chiarelli and Toward pads were developed between 2011 and 2015.

Hydraulic Fracking and well stimulation methods have led to rapid expansion of oil and gas development in the United States. This expansion has brought oil and gas development closer to backyards, schools, and communities and increased potential for exposure to new contaminants and threats. At the same time Health discussions have focused on mostly water contamination, but are now turning their attention to air pollutions issues as well. Although little is known about the environmental and public health impact of unconventional natural gas extraction activities, including hydraulic fracking that occur near residential areas, and schools that the most vulnerable of our population ;the children, attend.

I have included for you to view environmental health perspectives, which is a reported health status of results of a Household Survey done in Washington County published in December 2014, discussing the proximity to Natural Gas Wells and reported Health Symptoms. Their conclusion states: "Although these results should be viewed as hypothesis generating, and the population studied was limited to households with a ground fed water supply, proximity of natural gas wells may be associated with the prevalence of health symptoms including dermal and respiratory conditions in residents living near natural gas extraction activities. Further study of these associations, including the role of specific air and water exposures is warranted.'

Although you can argue how and what happens, it is known that children can not metabolize and process to remove toxins from their system as quickly as adults. These toxins and suspected air pollution emisssions, may be coming from any number of well associated activities such as increased truck traffic, fracking process, fracking chemical, and other processes used in the extraction and active drilling processes, that are fully described in the package I have presented to you, under the Process of Natural Gas Extraction.

I am submitting for your examination the medical records of one of these children at risk, my daughter, an active 11 year old who was unremarkably healthy in October 2011, 6 weeks later all that changed. It began with itchy watery eyes (I can not help but mention that it was later discovered to be the month and time frame that drilling activities had begun on the Chiarelli Pad near the school. Please refer to the photos. This pad is in the near ½ mile zone from the school (Fort Cherry).

Please continue to examine the medical records as symptoms continued through 2015 to the present day. Excessive bruising, polydipsia, fatigue, respiratory Infections, fever, headaches, cough, Gastro Disturbances, rashes, bullseye rashes, a trip to the Emergency Room, right wrist pain, swelling and

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inflammation of the joints, and the unexpected, unexplained, and unwelcome Bloody Noses. Most 11 year olds do not endure these symptoms, mine endures on a regular basis.

Recently on an X-Ray it was revealed sclerotic distal changes involving the right distal radial metophysis, which caused the doctor caring for my child to finally consider the possibility of Heavy Metal Exposures and testing was ordered. Having difficulty getting this testing done, these results are not available tonight. The waiting is Terrifying.

DEP and lawmakers including those at local and municipal levels as well as State must recognize the urgency and importance of distancing Industrial Activities from the Gas and Oil Industry including the drilling of wells, Tank Farms, Impoundments, Compression Stations, and operations, and any other pollution causing dangerous activity and our school properties from each other.

DEP must adopt more aggressive standards to prevent these activities from being located at least one mile from our schools and our children.

One Mile Away . . . . . .Is it SAFE enough for our children to STAY? ? ?

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Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Survey in Washington County, Pennsylvania

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Abstract About This Article Supplemental Material

Background: Little is known about the environmental and public health impact of unconventional natural gas extraction activities, including hydraulic fracturing, that occur near residential areas.

Objectives: Our aim was to assess the relationship between household proximity to natural gas wells and reported health symptoms.

Methods: We conducted a hypothesis-generating health symptom survey of 492 persons in 180 randomly selected households with ground-fed wells in an area of active natural gas drilling. Gas well proximity for each household was compared with the prevalence and frequency of reported dermal, respiratory, gastrointestinal, cardiovascular, and neurological symptoms.

Results: The number of reported health symptoms per person was higher among residents living < 1 km (mean ± SD, 3.27 ± 3.72) compared with > 2 km from the nearest gas well (mean ± SD, 1.60 ± 2.14; $p = 0.0002$). In a model that adjusted for age, sex, household education, smoking, awareness of environmental risk, work type, and animals in house, reported skin conditions were more common in households < 1 km compared with > 2 km from the nearest gas well (odds ratio = 4.1; 95% CI: 1.4, 12.3; $p = 0.01$). Upper respiratory symptoms were also more frequently reported in persons living in households < 1 km from gas wells (39%) compared with households 1–2 km or > 2 km from the nearest well (31 and 18%, respectively) ($p = 0.004$). No equivalent correlation was found between well proximity and other reported groups of respiratory, neurological, cardiovascular, or gastrointestinal conditions.

Conclusion: Although these results should be viewed as hypothesis generating, and the population studied was limited to households with a ground-fed water supply, proximity of natural gas wells may be associated with the prevalence of health symptoms including dermal and respiratory conditions in residents living near natural gas extraction activities. Further study of these associations, including the role of specific air and water exposures, is warranted.

Introduction

Unconventional methods of natural gas extraction, including directional drilling and hydraulic fracturing (also known as "fracking"), have made it possible to reach natural gas reserves in shale deposits thousands of feet underground (Myers 2012). Increased drilling activity in a number of locations in the United States has led to growing concern that natural gas extraction activities could contaminate water supplies and ambient air, resulting in unforeseen adverse public health effects (Goldstein et al. 2012). At the same time, there is little peer-reviewed evidence regarding the public health risks of natural gas drilling activities (Kovats et al. 2014; McDermott-Levy and Kaktins 2012; Mitka 2012), including a lack of systematic surveys of human health effects.

The process of natural gas extraction. Natural gas extraction of shale gas reserves may involve multiple activities occurring over a period of months. These include drilling and casing of deep wells that contain both vertical and horizontal components as well as placement of underground explosives and transport and injection of millions of gallons of water containing sand and a number of chemical additives into the wells at high pressures to extract gas from the shale deposits (hydraulic fracturing) (Jackson RE et al. 2013). Chemicals used in the hydraulic fracturing process can include inorganic acids, polymers, petroleum distillates, anti-scaling compounds, microbicides, and surfactants (Vidic et al. 2013). Although some of these fluids are recovered during the fracking process as "flowback" or "produced" water, a significant amount (as much as 90%) (Vidic et al. 2013) may remain underground. The recovered flowback water—which may contain chemicals added to the fracking fluid as well as naturally occurring chemicals such as salts, arsenic, and barium and naturally occurring radioactive material originating in the geological formations—may be stored in holding ponds or transported offsite for disposal and/or wastewater treatment elsewhere.

Potential water exposures. Although much of the hydraulic fracturing process takes place deep underground, there are a number of potential mechanisms for chemicals used in the fracturing process as well as naturally occurring minerals, petroleum compounds (including volatile organic compounds; VOCs), and other substances of flowback water (Chapman et al. 2012) to enter drinking-water supplies. These include spills during transport of chemicals and flowback water, leaks of a well casing (Kovats et al. 2014), leaks through underground fissures in rock formations, runoff from drilling sites, and disposal of fracking flowback water (Rozell and Reaven 2012). Studies have reported increased levels of methane in drinking water wells located < 1 km from natural gas drilling, suggesting contamination of water wells from hydraulic fracturing activities (Jackson RB et al. 2013; Osborn et al. 2011), although natural movement of methane and brine from shale deposits into aquifers has also been suggested (Warner et al. 2012). If contaminants from hydraulic fracturing activities were able to enter drinking water supplies or surface water bodies, humans could be exposed to such contaminants through drinking, cooking, showering, and swimming.

Potential air exposures. The drilling and completion of natural gas wells, as well as the storage of waste fluids in containment ponds, may release chemicals into the atmosphere through evaporation and off-gassing. In Pennsylvania, flowback fluids are not usually disposed of in deep injection wells; therefore surface ponds containing flowback fluids are relatively common and could be sources of air contamination through evaporation. Flaring of gas wells, operation of diesel equipment and vehicles, and other point sources for air quality contamination around drilling activities may also pose a risk of respiratory exposures to nitrogen oxides, VOCs, and particulate matter. Release of ozone precursors into the environment by natural gas production activities may lead to increases in local ozone levels (Olaguer 2012). Well completion and gas transport may cause leakage of methane and other greenhouse gases into the environment (Allen 2014). Studies in Colorado have reported elevated air levels of VOCs including trimethylbenzenes, xylenes, and aliphatic hydrocarbons related to well drilling activities (McKenzie et al. 2012).

Human health impact. Concerns about the impact of natural gas extraction on the health of nearby communities have included exposures to contaminants in water and air described above as well as noise and social disruption (Witter et al. 2013). A published case series cited the occurrence of respiratory, skin, neurological, and gastrointestinal symptoms in humans living near gas wells (Bamberger and Oswald 2012). A convenience sample survey of 108 individuals in 55 households across 14 counties in Pennsylvania who were concerned about health effects from natural gas facilities found that a number of self-reported symptoms were more common in individuals living near gas facilities, including throat and nasal irritation, eye burning, sinus problems, headaches, skin problems, loss of smell, cough, nosebleeds, and painful joints (Steinzor et al. 2013). Similarly, a convenience sample survey of 53 community members living near Marcellus Shale development found that respondents attributed a number of health impacts and stressors to the development. Stress was the symptom reported most frequently (Ferrar et al. 2013).

Here we report on the analysis of a cross-sectional, random-sample survey of the health of residents who had ground-fed water wells in the vicinity of natural gas extraction wells to determine whether proximity to gas wells was associated with reported respiratory, dermal, neurological, or gastrointestinal symptoms.

Methods

Selection of study area. The Marcellus formation, a principal source of shale-based natural gas in the United States, is a Middle Devonian–age black, low-density, organically rich shale that has been predominantly horizontally drilled for gas extraction in the southwestern portion of Pennsylvania since 2003 [Pennsylvania Spatial Data Access (PASDA) 2013]. In this study we focused on Washington County in southwestern Pennsylvania, an area of active natural gas drilling (Carter et al. 2011). At the time of the administration of the household survey during summer 2012, there were, according to the Pennsylvania Department of Environmental Protection, 624 active natural gas wells in Washington County. Of these natural gas wells, 95% were horizontally drilled (Pennsylvania Department of Environmental Protection 2012). The county has a highly rural classification with nearly 40% of the land devoted to agriculture (U.S. Department of Agriculture 2007). Washington County has a population of approximately 200,000 persons with 94% self-identified as white, 90% having at least a high school diploma, and a 2012 median household income of $53,545 (Center for Rural Pennsylvania 2014). We selected a contiguous set of 38 rural townships within the center of Washington County as our study site in order to avoid urban areas bordering Pittsburgh, which would be unlikely to have ground-fed water wells, and areas near the Pennsylvania border, which might be influenced by gas wells in other states (Figure 1).

Figure 1 – Distribution of drilled active Marcellus Shale natural gas wells (n = 624) and randomly generated sampling sites (n = 760) for eligible municipalities of Washington County, Pennsylvania.

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Survey instrument. We designed a community environmental health assessment of reported health symptoms and health status based on questions drawn from publicly available surveys. Symptom questions, covering a range of organ systems that had been mentioned in published reports (Bamberger and Oswald 2012; Steinzor et al. 2013), asked respondents whether they or any household members had experienced each condition during the past year (see Supplemental Material, "Questionnaire"). The health assessment also asked a number of general yes/no questions about concerns of environmental hazards in the community, such as whether respondents were satisfied with air quality, water quality, soil quality, environmental noise and odors, and traffic, but did not specifically mention natural gas wells or hydraulic fracturing or other natural gas extraction activities. The survey was pretested with focus groups in the study area in collaboration with a community based group and revised to ensure comprehensibility of questions.

Selection and recruitment of households. Using ArcGIS Desktop 10.0 software (ESRI, Inc., Redlands, CA), we randomly selected 20 geographic points from each of 38 contiguous townships in the study county (Figure 1). We identified an eligible home nearest to each randomly generated sampling point, and visited each home to determine which households were occupied and had ground-fed water wells. We selected households with ground-fed water wells to assess possible health effects related to water contamination. From the original 760 points identified (i.e., 20 points in each of the 38 townships), we excluded 12 duplicate points and 64 points found not to correspond to a house structure (see Supplemental Material, Figure S1). After site visits by the study team who spoke to residents or neighbors, we excluded house locations determined not to have a ground-fed well or spring. Additional points were excluded if the structure was not occupied ($n = 5$) or inaccessible from the road ($n = 4$). During visits to eligible households, a study member invited a responding adult at least 18 years of age to participate in the survey, described as a survey of community environmental health that considered a number of environmental health factors. Three households were excluded when the respondent was unable to answer the questionnaire due to language or health problems. Eligible households were offered a small cash stipend for participation.

The Yale University School of Medicine Human Research Protection Program determined the study to be exempt from Human Subjects review. Respondents provided oral consent but were not asked to sign consent forms; their names were not recorded.

Of the 255 eligible households, respondents refused to complete the survey in 47 households, and we were not able to contact residents in another 26 households. Reasons for refusal included "not interested" ($n = 8$), "no time/too busy" ($n = 3$), "afraid" ($n = 1$), and 35 gave no reason. The rate of refusal varied by distance category, with 12 of 74 (16%) of households < 1 km from a gas well, 10 of 67 (15%) of households 1–2 km from wells, and 25 of 86 (25%) of eligible households > 2 km from a gas well refusing to participate, but the differences were not statistically significant. At the consenting 180 households (71% of eligible households), an adult respondent completed the survey covering the health status of the 492 individuals living in these households.

Administration of survey at residence. Trained study personnel administered the survey in English. The responding adult at the participating household reported on the health status of all persons in the household over the past year. A study team member recorded the global positioning system (GPS) coordinates of the household using a Garmin GPSMAP® 62S Series handheld GPS device (Garmin International, Inc., Olathe, KS). Survey personnel were not aware of the mapping results for gas well proximity to the households being surveyed.

Household proximity to nearest active gas well and age of wells. A map of 624 active natural gas wells in the study area, and their age and type, was created by utilizing gas well permit data publicly available at the PASDA (2013). Ninety five percent of the gas wells had "spud dates" (first date of drilling) between 2008 and 2012, with more than half of spud dates occurring in 2010 and 2011. We used ArcGIS to calculate the distance between each household location (as defined by the GPS reading taken during the site visit) and each natural gas well in the study area. We then classified households according to their distance from the nearest gas well with distance categories of < 1 km, 1–2 km, or > 2 km. We used 1 km as the initial cut point for distance to a nearest gas well because of the reported association of higher methane levels in drinking-water wells located < 1 km from natural gas wells (Osborn et al. 2011), and 2 km as the second cut point because it was close to the mean of the distances between households and nearest gas wells. The mean and median distance between a household and the nearest natural gas well were 2.0 km and 1.4 km, respectively. We classified the age of each gas well as the time interval between spud date and the date that the household survey was conducted during summer, 2012.

Statistical analysis. Demographic variables were analyzed for differences among individuals between distance categories using chi-square, analysis of variance, or generalized linear mixed-model statistics as appropriate. Reported occupation was classified as either blue collar, office sales and service, management/professional, or not working, using classifications of the U.S. Bureau of Labor Statistics (2014).

The prevalence of each outcome and the number of symptoms reported for each household member included in the study were calculated according to the distance of each household (< 1, 1–2, or > 2 km) from the nearest gas well. To test the association between household distance from a well and the overall number of symptoms as well as the presence or absence of each of six groups of health conditions (dermal, upper respiratory, lower respiratory, gastrointestinal, neurological, and cardiovascular), we used SAS 9.3 in a generalized linear mixed model (GLMM) analysis (SAS Institute Inc., Cary, NC). The analysis used maximum likelihood estimation with adaptive quadrature methods (Schabenberger 2007) including a random effect for household to account for the clustering of individuals within a household. The model was adjusted for age of individual (continuous), sex (binary), average adult household education (continuous), smoker present in household (yes/no), awareness of environmental hazard nearby (yes/no), employment type (four categories), and whether animals were present in the home or backyard (yes/no). Given the exploratory nature of this study, no adjustments were made for multiple comparisons and significance was established at the two-sided 0.05 level. Statistical analyses were conducted using SAS 9.3.

Results

Demographics. Individuals living in households < 1 km from gas wells were older (mean, 46.9 ± 21.9) compared with individuals in households > 2 km from a gas well (mean, 40.0 ± 23.5 years, $p = 0.03$) (Table 1). There was a higher proportion of children in the households > 2 km from a gas well compared with those < 1 km from a gas well (27% vs. 14%, $p = 0.008$). Families had lived in their homes an average of 22.8 ± 17.2 years at the time of the interview. Thirty-four percent of individuals had blue-collar jobs and 38% of the subjects were nonworkers (e.g., unemployed, students). Sixty-six percent reported using their ground-fed water (well or natural spring) for drinking water, and 84% reported using it for other activities such as bathing. The age of the nearest gas well was significantly greater for households < 1 km from a gas well (mean, 2.3 ± 1.6) compared with those 1–2 km or > 2 km from a well (1.5 ± 1.3 and 1.1 ± 0.9, respectively, $p < 0.05$). Reported smoking was less common in households near gas wells, whereas reported respondent awareness regarding environmental health risks was higher, although these differences were not statistically significant.

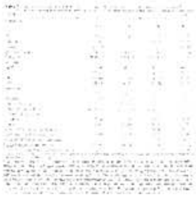

Table 1 – Demographics and household characteristics by proximity to the nearest natural gas well.

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Reported health symptoms. The average number of reported symptoms per person in residents of households < 1 km from a gas well (3.27 ± 3.72) was greater compared with those living > 2 km from gas wells (1.60 ± 2.14, $p = 0.0002$).

Individuals living in households < 1 km from natural gas wells were more likely to report having any of the queried skin conditions over the past year (13%) than residents of households > 2 km from a well (3%; $\chi^2 = 13.8$, $p = 0.001$) (Table 2). Reported upper respiratory symptoms were also more frequent among households < 1 km (39%) compared with households > 2 km from gas wells (18%; $\chi^2 = 17.9$, $p = 0.0001$).

Table 2 – Prevalence of selected health conditions reported by individuals by proximity to the nearest gas well (2011 –2012).[a]

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In a hierarchical model that adjusted for age, sex, household education level, smokers in household, job type, animals in household, and awareness of environmental risk (Table 3), household proximity to natural gas wells remained associated with number of symptoms reported per person < 1 km ($p = 0.002$) and 1–2 km ($p = 0.05$) compared with > 2 km from gas wells, respectively. In similar models, living in a household < 1 km from the nearest gas well remained associated with increased reporting of skin conditions [odds ratio (OR) = 4.13; 95% confidence interval (CI): 1.38, 12.3] and upper respiratory symptoms (OR = 3.10; 95% CI: 1.45, 6.65) compared with households > 2 km from the nearest gas well.

Table 3 – Associations of nearest gas well proximity and symptoms.

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For the other grouped symptom complexes examined, there was not a significant relationship in our adjusted model between the prevalence of symptom reports and proximity to nearest gas well. In the multivariate model, however, environmental risk awareness was significantly associated with report of all groups of symptoms.

Age of the nearest gas well was found to be negatively correlated with distance ($r = -0.325$; $p < 0.0001$): Gas wells < 1 km from households tended to be older than the nearest wells in other distance categories. When age of wells was added to the multivariate model, proximity to gas wells remained significantly associated with respiratory symptoms, but the association between proximity and dermal symptoms lost statistical significance.

Discussion

This spatially random health survey of households with ground-fed water supply in a region with a large number of active natural gas wells is to our knowledge the largest study to date of the association of reported symptoms and natural gas drilling activities.We found an increased frequency of reported symptoms over the past year in households in closer proximity to active gas wells compared with households farther from gas wells. This association was also seen for certain categories of symptoms, including skin conditions and upper respiratory symptoms. This association persisted even after adjusting for age, sex, smokers in household, presence of animals in the household, education level, work type, and awareness of environmental risks. Other groups of reported symptoms, including cardiac, neurological, or gastrointestinal symptoms, did not show a similar association with gas well proximity. These results support the need for further investigation of whether natural gas extraction activities are associated with community health impacts.

These findings are consistent with earlier reports of respiratory and dermal conditions in persons living near natural gas wells (Bamberger and Oswald 2012; Steinzor et al. 2013). Strengths of the study included the larger sample size compared with previously published surveys, and the random method of selecting households using geographic information system methodology, which reduces the possibility of selection bias (although only a subset of households, those with ground-fed water supply, were sampled).

A limitation of the study was the reliance on self-report of health symptoms. On one hand, symptoms in other household members may have been underreported by the household respondent; on the other hand, awareness bias in individuals concerned about the presence of an environmental health hazard would be more likely to increase reporting of illness symptoms, leading to recall bias of the results. We did not collect data on whether individuals were receiving financial possible that differential refusal to participate could have introduced potential for selection bias; for example, individuals who were receiving compensation for gas drilling on their property might be less willing to participate in the survey. We found instead that the refusal rate, though < 25% overall, was higher among households farther from gas wells, suggesting that such households may have been less interested in participating because they had less awareness of hazards. The study questionnaire did not include questions about natural gas extraction activities, in order to reduce awareness bias. At the same time, it is likely that household residents were aware of gas drilling activities in the vicinity of households; and the fact that reported environmental awareness by respondents was associated with the prevalence of all groups of reported health symptoms suggests a correlation between heightened awareness of health risks and reported health conditions. Nevertheless, the observed association between gas well proximity and reported dermal and upper respiratory symptoms persisted in the multivariate model even after adjusting for environmental awareness. Future studies should attempt to medically confirm particular diagnoses and further assess and control for the effect of awareness on reported health status.

A further study limitation was the fact that our analysis includes multiple comparisons between groups of households, and the consequent possibility that random error could account for some of our findings. We limited such comparisons by grouping individual symptoms into organ system clusters. However, we acknowledge that the multiple comparisons used in the methodology mean that any such particular findings should be viewed as preliminary and hypothesis generating.

Our use of gas well proximity as a measure of exposure was an indirect measure of potential water or airborne exposures. More precise data could come from direct monitoring and modeling of air and water contaminants, and correlating such measured exposures with confirmed health effects should be a focus of future study. Biomonitoring of individuals living near natural gas wells could provide additional information about the role and extent of particular chemical exposures.

There are several potential explanations for the finding of increased skin conditions among inhabitants living near gas wells. One is that natural gas extraction wells could have caused contamination of well water through breaks in the gas well casing or other underground communication between ground water supplies and fracking activities. The geographic area studied has experienced petroleum and coal exploration and extraction activities in the past century, and such activities may increase the risk of chemicals in fracking fluid or flowback water entering ground water and contaminating wells. If such contamination did occur, several types of chemicals in fracking fluid have irritant properties and could potentially cause skin rashes or burning sensation through exposure during showers or baths. There are published reports of associations between the prevalence of eczema and other skin conditions with exposure to drinking water polluted with chemicals including VOCs (Chaumont et al. 2012; Lampi et al. 2000; Yorifuji et al. 2012) as well as changes in water hardness (Chaumont et al. 2012; McNally et al. 1998).

A second possible explanation for the skin symptoms could be exposure to air pollutants including VOCs, particulates, and ozone from upwind sources, such as flaring of gas wells (McKenzie et al. 2012) and exhaust from vehicles and heavy machinery.

A third possibility to explain the clustering of skin and other symptoms would be that they could be related to stress or anxiety that was greater for households living near gas wells. In this study, awareness of environmental risk was independently associated with overall reporting of symptoms as well as reporting of skin problems. However, in multivariate models, proximity to gas wells remained a significant predictor of symptoms even when adjusting for such awareness. These results argue for possible air or water contaminant exposures, in addition to stress, contributing to the observed patterns of increased health symptoms in households near gas wells. A fourth possibility would be the role of allergens or irritant chemicals not related to natural gas drilling activities, such as exposure to agricultural chemicals or household animals. We did not see a correlation between skin conditions and either the presence of an animal in the household or agricultural occupation, making this association less likely. At the same time, it is possible that other confounding could be present but not accounted for in our models.

Our findings of increased reporting of upper respiratory symptoms among persons living < 1 km from a natural gas well suggests that airborne irritant exposures related to natural gas extraction activities could be playing a role. Such irritant exposures could result from a number of activities related to natural gas drilling, including flaring of gas wells and exhaust from diesel equipment. Because other studies have suggested that airborne exposures could be a significant consequence of natural gas drilling activity, further investigation of the impact of such activities on respiratory health of nearby communities should be investigated. Future studies should collect such data.

Since most of the gas wells in the study area had been drilled in the past 5–6 years, one would not yet expect to see associations with diseases with long latency, such as cancer. Furthermore, if some of the impact of natural gas extraction on ground water happens over a number of years, this initial survey could have failed to detect health consequences of delayed contamination. However, if the finding of skin and respiratory conditions near gas wells indicates significant exposure to either fracking fluids and chemicals or airborne contaminants from natural gas wells, studies looking at such long-term health effects in chronically exposed populations would be indicated.

Conclusions

The results of this study suggest that natural gas drilling activities could be associated with increased reports of dermal and upper respiratory symptoms in nearby communities; these results support the need for further research into health effects of natural gas extraction activities. Such research could include longitudinal assessment of the health of individuals living in proximity to natural gas drilling activities, medical confirmation of health conditions, and more precise assessment of contaminant exposures.

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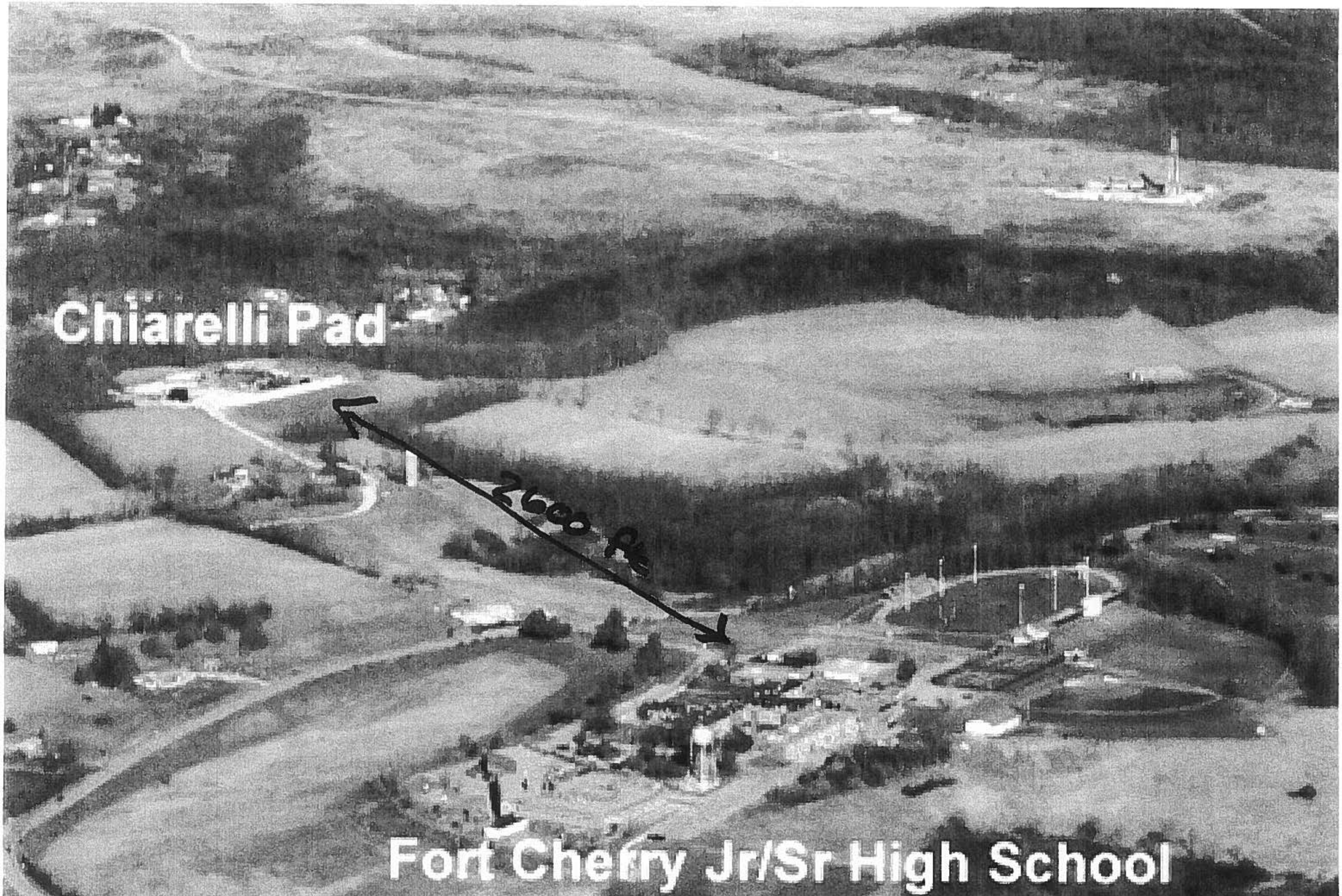
Chiarelli Pad
2600 ft
Fort Cherry Jr/Sr High School

UPMC LIFE CHANGING MEDICINE

200 Lothrop Street 412-864-538
Pittsburgh, PA 15213-2582
Phone [redacted]
MD #
DEA

Name [redacted]
Address
Age 11
Date 4/9/15
Refill ______ times

Rx

(1) whole blood lead level   Re. possible heavy metal exposure

please fax results to primary care physician (Mannali, Henri) and to UPMC Medical Toxicology @ 412-864-3993

Michael Abesamis, MD
Physician's name (please print)

______, MD
(signature)

In order for a brand name product to be dispensed, the prescriber must handwrite "Brand Necessary" or "Brand Medically Necessary" in the space below.

Not valid for Schedule II drugs

UPMC-05295-0612

Security features: reflective watermark on back; "void" pantograph when copied; erasure resistance

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3108N-QUEST

UPMC LIFE CHANGING MEDICINE

200 Lothrop Street
Pittsburgh, PA 15213-2582
Phone 412-864-5382
MD #
DEA

Name [redacted]
Address
Age 11
Date 4/9/15
Refill ______ times

Rx

(1) Aromatic solvent metabolites in urine (2302U)
Re: possible exposure/environmental hydrocarbon expo

(2) Aromatic solvent panel in blood (0785B)
Re: possible exposure/environmental hydrocarbon exposure

Michael Abesamis, MD
Physician's name (please print)

______, MD
(signature)

In order for a brand name product to be dispensed, the prescriber must handwrite "Brand Necessary" or "Brand Medically Necessary" in the space below.

Not valid for Schedule II drugs

UPMC-05295-0612

THE WASHINGTON HOSPITAL

PATIENT: [redacted]
MED REC#: [redacted]
ADMIT DATE: 03/19/2015 - 16:20
DATE of SERVICE: 03/19/2015 - 16:39

SEX: F AGE: 11 YRS DOB: 10/29/2003
ACCT.#: [redacted]
ROOM: NHC
DISCHG DATE:

ATTENDING PHYS: Manuel, Mervin
REFERRING PHYS:
ORDERING PHYS: Manuel, Mervin

WRIST-RT

Accession Number: 5293546
Report Date: 03/20/15
Ordering Physician replaced in message to allow for electronic delivery. Actual Ordering Physician: Dr. MERVIN MANUEL
Reading Radiologist: WILLIAM DOWNER

EXAMINATION PERFORMED
WRIST-RT

CLINICAL HISTORY
Patient complains of pain for the past 2-3 weeks 2 the radial aspect of the right wrist patient reports no known trauma

TECHNIQUE
AP lateral and oblique views of the right wrist reviewed. Of an AP comparison view of the left wrist.

COMPARISON
No old studies are available for comparison

FINDINGS
There is some sclerotic change involving the right distal radial metaphysis. This is greater than seen on the left. No fracture is identified. The growth plate and epiphysis of the distal right radius appear normal. Distal lright ulna appears normal. Carpal bones are intact. Scapholunate space is not widened. Metacarpals appear intact.

IMPRESSION
There is increased sclerotic change involving the distal right radial metaphyais relative to the distal left radial metaphysis. Etiology is indeterminate. I do not see a fracture. The distal right radial growth plate remains open. The distal right radial epiphysis normal.
Verified by: DOWNER, Performed On :03/19/2015 16:39:00
Ordering Physician may have been replaced in message to allow for electronic delivery. Actual Ordering Physician: Dr. MERVIN MANUEL

END OF REPORT

UPMC LIFE CHANGING MEDICINE

University of Pittsburgh Physicians
Department of Emergency Medicine
Division of Medical Toxicology

3600 Forbes Ave
Iroquois Building, Suite 402
Pittsburgh, PA 15261
Phone :(412)-864-5382
Fax : 412-864-3993

April 6, 2015

Jane Worthington
135 Main Street
Hickory, PA 15340

Dear Ms. Worthington,

Your granddaughter [redacted] confirmed for an appointment to see Dr. Michael Abesamis in the Medical Toxicology Outpatient clinic on Thursday, April 9, 2015 at 3:00 pm. The clinic is located in the Emergency Department (ED) on the lobby level of UPMC Presbyterian Hospital. Please report to the ED triage/check-in desk upon your arrival. UPMC Presbyterian is located at 200 Lothrop Street, Pittsburgh, PA, 15213. A map for directions to this hospital is enclosed for your convenience and valet parking is available outside the entrance to UPMC Presbyterian.

Also enclosed is a Medical and Occupational History form that should be completed by you for your appointment on April 9th. Please bring this completed form with you at the time of your visit.

If you are unable to make this appointment, (24 hour advance cancellation is recommended), please notify our administrative office at 412-864-5382. Please contact the triage/check-in desk directly at 412-647-3319 if you think you may be late for your appointment.

If you have any questions about your visit, please do not hesitate to contact me.

Sincerely,

Maureen A Morgan

Maureen A. Morgan
Division of Medical Toxicology
Department of Emergency Medicine
University of Pittsburgh Medical Center

Enclosures

NRDC ISSUE BRIEF

DECEMBER 2014
IP:14-10-A

Fracking Fumes: Air Pollution from Hydraulic Fracturing Threatens Public Health and Communities

Just off Interstate Highway 25, Drill Rig in front of homes in the town of Frederick in Weld County, Colorado. Pipes, vehicles and storage tanks also stand in front of homes as hazy, snow capped Rocky Mountains stand in the background.

Tanja Srebotnjak
Miriam Rotkin-Ellman
Natural Resources Defense Council

INTRODUCTION

Hydraulic fracturing ('fracking') and other well stimulation methods have led to a rapid expansion of oil and gas development in the United States.[1] This expansion has brought oil and gas development closer to backyards and communities and increased the potential for human exposure to new contaminants and threats. At the same time, a growing body of new research points to health threats from unconventional oil and gas development and fracking in particular. Although health discussions, particularly in eastern states, have focused on drinking water contamination, there is mounting evidence for a range of health threats from air pollution as well. For example, research has linked pollution from fracking to unhealthy levels of smog and of toxic air contaminants. Exposure to this pollution can cause eye, nose, and throat irritation, respiratory illnesses, central nervous system damage, birth defects, cancer, or premature death.[2] At the same time, the oil and gas industry has been exempted from many regulations that limit air pollution from industrial activity.[3] At the federal level, the Environmental Protection Agency (EPA) recently issued new standards to limit harmful air pollution from the oil and gas industry—but these still contain major gaps.[4] Health protective regulations are also hampered by lack of scientific data on the potential cumulative risks posed by the combined emissions from a dense network of wells and associated infrastructure such as pipelines, compressor stations, and roads. State regulations are patchy and enforcement often cannot keep up with the industry's rapid expansion, resulting in insufficient protection from air pollutants.

HEALTH STUDIES FIND IMPACTS FROM FRACKING-RELATED AIR POLLUTION

Conventional oil and gas production has been known for some time to create harmful air emissions.[5] With the increase in fracking activity, more and more studies now document emissions of airborne pollutants at and near fracking sites that are known to cause cancer and harm the nervous, respiratory, and immune systems (see Figure 1). At the same time, people and communities in areas with many hydraulically fractured wells report health problems consistent with these types of exposures.[6,7,8,9,10] While it is difficult to measure actual exposures to pollutants from nearby fracking operations and establish clear links to adverse health outcomes, some studies found associations between air pollutants that are present at oil and gas production sites and health impacts observed in nearby communities.[11,12] In Colorado, for example, an evaluation of birth defects in areas with high concentrations of oil and gas activity found that mothers who lived near many oil and gas wells were 30 percent more likely to have babies with heart defects.[13] Similarly, preliminary results from a study in Pennsylvania show impacts among newborns that could be linked to air pollution such as increases in low birth weight.[14]

In many rural areas, the boom in oil and gas activity has been linked to unhealthy spikes in ozone concentrations.[15] In 2008 and 2011, increased ozone concentrations in Wyoming's Sublette County were associated with subsequent increases in outpatient clinic visits for respiratory problems.[16] Researchers who looked at air pollution levels near fracking sites in Colorado also found an increased risk of chronic and sub-chronic effects mainly stemming from oil and gas related pollutants, which can harm the respiratory and neurological systems and lead to symptoms like shortness of breath, nosebleeds, headaches, dizziness, and chest tightness.[17]

Thus, while research into the health effects of air pollution from unconventional oil and gas development is ongoing, there is mounting evidence that it causes pollution, which can affect the health of workers and communities.

Figure 1: Summary of major health effects associated with the release of airborne pollutants from fracking

AIR POLLUTION FROM FRACKING

A comprehensive literature review identified 15 different oil and gas development processes and sources—including the drilling process, wastewater, and condensate tanks—that can release air contaminants (see Figure 2 in the Appendix).[18] The authors conclude that "there is legitimate concern that local air pollution may produce adverse effects in individuals who live near the high emitting site or processes." The rapid expansion of fracking, both in areas with existing oil and gas operations and previously undrilled areas, can lead to an increase in the type of pollution generally found at conventional oil and gas development and to other pollutants specific to fracking, such as silica sand, fracking chemicals, and flowback wastewater.

Local Impacts

Diesel Emissions

Diesel emissions originate from the combustion engines of heavy trucks and machinery used during well site preparation, drilling, and production. Exhaust from diesel engines contains hundreds of toxic chemicals. Of greatest concern is the fine diesel soot particles, which can lodge deep within the lungs, increasing health risks including: emergency room visits, hospital admissions, asthma attacks, cardiopulmonary disease (including heart attack and stroke), respiratory disease, adverse birth outcomes, and premature death (from pneumonia, heart attack, stroke and lung cancer).[19,20] Researchers are concerned about local residents' increased risk of exposure to diesel exhaust.[21] A study of regional air quality impacts from natural gas extraction in Pennsylvania's Marcellus Shale included diesel emissions from truck traffic, well drilling and hydraulic fracturing, gas production, on-site combustion, and compressor stations in the monetary damage calculations.[22] The National Institute for Occupational Safety and Health (NIOSH) expressed concern about the levels of diesel particulate matter measured at 11 oil and gas sites in Colorado, Arkansas, Pennsylvania, Texas, and North Dakota.[23]

Toxics

Toxic air pollutants originate from direct and fugitive emissions of hydrocarbons at the well and from associated infrastructure such as condensate tanks, dehydrators, wastewater impoundment pits, and pipelines. The fracking process involves dozens of chemicals and the process returns oil, gas, fracking chemicals, formation brines, and mobilized compounds, including heavy metals and naturally occurring radioactive materials (NORM) to the surface.

Hydrogen sulfide (H_2S) is a toxic and explosive gas that may be present in oil and gas formations and is produced along with the hydrocarbons. It is damaging to the central nervous system and can be lethal at higher concentrations (~1000 ppm).[24] While oil and gas workers may be required to wear protective respirators,[25] no such protections are considered for surrounding communities.

Benzene, toluene, ethylbenzene, and xylene (BTEX) and other toxic hydrocarbons, such as formaldehyde, released from oil and gas operations and equipment can lead to health impacts ranging from irritation of eyes, nose, mouth, and throat to aggravated asthma and other respiratory conditions, blood disorders, harm to the developing fetus, immune system-related diseases, and cancer (e.g., leukemia, non-Hodgkins lymphoma).

A study commissioned by the West Virginia Department of Environmental Protection found that, at many sites, a 625-feet distance from oil and gas activity—above the distances set by many states—still resulted in benzene concentrations above levels the Center for Disease Control and Prevention (CDC) considers "the minimum risk level for no health effects."[26] At least one of the BTEX compounds was found at all of the seven drilling sites examined. A health risk assessment in Colorado's heavily drilled Garfield County identified many hydrocarbon pollutants (including trimethylbenzenes, aliphatic hydrocarbons, and xylenes) associated with adverse respiratory and neurological effects.[27] It further found that concentrations of benzene, toluene, ethylbenzene, and xylene increased with proximity to the well site and were up to nine times higher during well completion than during well production. In tight gas fields in rural northeastern Utah, researchers estimated the total annual mass flux of volatile organic compounds (VOCs) from the surveyed gas fields to be equivalent to the emissions from 100 million cars.[28] The benzene levels measured in this study also exceeded health standards set by the Agency for Toxic Substances Disease Registry (ATSDR) and the California Environmental Protection Agency (CalEPA) to protect against harm to the developing fetus, immune system and blood.

Silica

Silica—the main component of 'frac sand'—is used widely and in large quantities to hold open the fractures created during the fracking process.[29] Inhalation of respirable silica can cause silicosis, an irreversible lung disease,[30] as well as lung cancer in miners, sandblasters, and foundry workers.[31] Silica inhalation is now also recognized as an occupational health hazard among oil and gas workers. NIOSH researchers collected 111 personal breathing zone (PBZ) samples at 11 sites in 5 states. At each one, they found that full-shift samples exceeded occupational health criteria,[32] in some cases by 10 times or more. This means that even if workers are properly using half-mask air-purifying respirators, they would not be sufficiently protected, because the measured concentrations exceed the masks' maximum use concentration.[33]

Regional Pollution

Ozone smog

Fracking-related processes and other stages of the oil and gas production process release nitrogen oxides and VOCs, which react in the presence of sunlight to form ozone ('smog'). Exposure to ozone is associated with a variety of respiratory and cardiovascular effects, including shortness of breath, reduced lung function, aggravated asthma and chronic respiratory disease symptoms, inflammatory processes, and premature death.[34] A growing number of studies have attributed emissions of ozone precursors from rapidly growing oil and gas development[35] to significantly elevated ozone concentrations in Wyoming,[36] Colorado,[37] Utah,[38,39,40] Pennsylvania,[41,42] Texas,[43,44] and Oklahoma.[45] In the study on Wyoming's Sublette County, tight gas production activities caused winter ozone levels[46] to spike above the EPA's 8-hour ozone standard of 75 parts per billion 13 times between February 14 and March 15, 2011.[47] In Utah's Uintah Basin ambient 1-hour ozone levels exceeded 150 ppb—twice the federal standard.[48]

Workers Not Protected

In addition to the community health concerns from fracking, worker safety at oil and gas production sites is also coming under increased scrutiny, in part because the oil and gas industry is one of the most dangerous occupational sectors in the country. According to statistics released by the Bureau of Labor Statistics there were 545 fatalities at U.S. oil fields between 2008 and 2012, of which 216 occurred in Texas.[49] At this level, the industry's fatality rate is 2.5 times higher than the accident-prone construction sector and more than 8 times higher than the industrial sector as a whole.[50] A major contributing factor to the industry's high fatality rate are traffic accidents, which also impact neighboring communities.

On-site toxic exposures present another health hazard to oil and gas workers. In 2010, at least four worker deaths may be linked to chemical and petroleum vapor exposure at or near flowback tanks at oil well sites in North Dakota and Montana.[51] Air samples collected by NIOSH in the personal breathing zone of workers at six flowback sites in Colorado and Wyoming identified benzene as the primary VOC of concern, especially near the hatches of the flowback tanks. Of the 17 samples, 15 met or exceeded the NIOSH Recommended Exposure Limit (REL) of 0.1 ppm.[52]

The unprotected inhalation of silica dust and diesel fumes also threatens worker health and may lead to cancers and other illnesses many years after exposure.[53] Workers may even bring contaminated clothes and boots home, putting their families at risk.

CURRENT POLICIES AND REGULATIONS PROVIDE INADEQUATE HEALTH PROTECTIONS

The oil and gas industry enjoys numerous exemptions from parts of key environmental and health protection laws, including the Clean Air Act, the Clean Water Act, and Hazardous Waste Laws.[54] These exemptions lead to weak regulations and inadequate monitoring for air pollutants and toxins from oil and gas facilities. As fracking and other extreme stimulation techniques move closer to towns and cities, this creates an information, legal, and regulatory vacuum that hampers communities' knowledge of and ability to protect themselves from harmful oil- and gas-related emissions and associated health impacts.

Faulty Inventories Underestimate Air Pollution

State and federal inventories provide important information for tracking and regulating air emissions of greenhouse gases, VOCs, and other hazardous air pollutants. Recent research indicates that these inventories may significantly underestimate air pollution from the oil and gas sector for a variety of reasons, including data gaps, uncertainty in the efficiency of emissions control equipment, use of obsolete or unrealistic emissions factors, incomplete reporting by operators, and changes in industry practices. One investigation led by the National Oceanic and Atmospheric Administration (NOAA) in Colorado's heavily drilled Denver-Julesburg Basin concludes that the state inventory for total VOCs emitted by oil and gas activities—which contribute to ozone formation and cause local toxicity—may be too low by a factor of at least two and that benzene emissions are seven-fold higher than reported in the state inventory.[55] An earlier systematic review of eleven "top-down" (starting with levels of pollutants in the atmosphere and attributing those emissions to sources) and a number of "bottom-up" (starting with measurement of a set of sources' emissions and extrapolating to aggregate emissions) studies looking at methane emissions from the sector estimates that total U.S. methane emissions from all sources were 25 percent to 75 percent higher than the U.S. Greenhouse Gas Inventory estimates for 2011, and finds that oil and gas are important contributors to these unreported emissions.[56] This review also concludes that a small number of "superemitters" could be responsible for a large fraction of the industry's methane leakage that had not been accounted for in the Inventory. In sum, the studies strongly suggest that oil and gas development is making a larger contribution to climate change than previously thought and that inventories may underestimate other pollutants.

Gaps in Federal Air Quality Regulations

In 2012, EPA issued two urgently needed standards aimed at limiting dangerous air pollution from oil and gas operations, including gas wells that are hydraulically fractured.[57] Although the rules are an improvement over the status quo, they fall short of the full level of health protection needed. The new rules, which are scheduled to take effect in 2015, will reduce well-site VOC emissions by 95 percent, but EPA monitoring will rely heavily on self-reported emissions data and the rules only apply to new gas wells and existing well sites will not be required to reduce pollution. In addition, the EPA still allows up to one ton of BTEX emissions from single glycol dehydrators per year.[58] And EPA relied relied on an analysis of health risks that was based on inadequate, inaccurate and incomplete emission inventories, ommitted pollutants with adverse health effects, excluded several sources of pollution, and failed to protect the most vulnerable populations.[59] The rules also fail to consider existing best practices that are already being deployed by many facilities to control pollution and prevent health impacts to surrounding communities. These technologies—such as improved efficiency, leak prevention systems, and emission controls—are readily available, feasible, and can even save the industry money.[60]

Lacking Enforcement

Federal and state agencies in charge of monitoring and enforcing oil and gas regulations have been overwhelmed by the industry's rapid growth. The Bureau of Land Management (BLM), charged with inspecting wells on federal lands and designating 'high priority wells' in need of greater environmental and groundwater protection, inspected only 40 percent of the 3,486 high priority wells between 2009 and 2012.[61] State oil and gas regulators, environmental protection departments, and public health agencies are left to fill in the gaps created by inadequate and constrained federal regulatory oversight. The result is a patchwork of state regulations and a distribution of responsibilities that leaves many loopholes and is plagued by a lack of resources for adequate inspections and enforcement. The Pennsylvania Department of Environmental Protection (DEP), for example, inspected fewer than 14 percent of active wells[62] and only 20 percent of producing wells in 2011.[63] A report for Texas found that enforcement actions were brought on only 2 percent of 55,000 logged violations.[64] There are no comprehensive national figures on enforcement in the oil and gas sector and state records are inconsistent in detail and accessibility.[65]

Companies are not mandated by federal regulations to disclose the identities or quantities of chemicals used during hydraulic fracturing operations on private or public lands. These chemicals can volatilize into the air from tanks and wastewater impoundments and contribute to air pollution. Some states have begun to set their own rules for chemical disclosure. Unfortunately, these laws often have shortcomings, including the non-disclosure of the composition of proprietary or "trade secret" fracking fluid products, insufficient penalties for reporting inaccurate or incomplete information, and allowances for after-the-fact reporting.[66] The industry-funded fracking fluid disclosure website FracFocus.org has been criticized in a review by researchers at Harvard Law School for inadequate transparency, accuracy, and user-friendliness.[67] The researchers concluded that "FracFocus is not an acceptable regulatory compliance method for chemical disclosures," but it is the official reporting site used by at least 11 states.[68]

These limitations leave lawmakers, regulators, public safety officers, and the public uninformed and ill-prepared to anticipate and respond to possible environmental and health hazards and emergencies associated with hydraulic fracturing fluids.

CONCLUSIONS

There is mounting evidence that air pollution from oil and gas operations threaten the health of nearby communities and immediate protections are needed. They should have the right to protect themselves by restricting or prohibiting these techniques within their jurisdictions. Where possible, ongoing unconventional oil and gas development should be put on hold to conduct comprehensive health assessments before determining whether or how these technologies should be allowed to proceed. In areas already bearing the brunt of fracking-related pollution and with no moratoria, strong safeguards are needed to control emissions and limit pollution.

RECOMMENDATIONS

The following is needed to ensure comprehensive health protections from air pollution:

- Protective standards at the federal and state level for communities and workers that ensure pollution controls including but not limited to:
    - Reduced Emission Completions (REC), also known as "green completion," to reduce methane and other VOC leaks for all wells, not only gas wells[69]
    - Leak detection and repair (LDAR) programs
    - Advanced technologies to control fugitive emissions
    - Reduction of diesel particulate matter through the use of cleaner combustion engines and alternative fuel types
    - Limitations on venting and flaring gas associated with oil production and ensuring that all gas is captured and sold or used on-site

- Comprehensive characterization of all pollution sources in unconventional oil and gas development and quantitative assessment of pollutants and emission rates through research and updated federal and state inventories
- Improved air quality monitoring before, during, and after well development and around all sources
- Expansion of the federal and state ozone monitoring network to better characterize air quality in rural areas highly impacted by pollution from oil and gas development
- Identification and implementation of adequate and protective setback requirements to reduce the exposure of residents to intermittent and chronic levels of air pollutants and toxins[70]
- Closure of regulatory loopholes in federal environmental programs to fill data gaps, increase transparency and oversight of the oil and gas industry and ensure public health protections
- Rigorous scientific studies in regions with intensive oil and gas development examining the effects of air pollution on the health of the local population, including comprehensive health impact assessments prior to new site development and followed by ongoing evaluations.[71]

WHAT RESIDENTS CAN DO

Residents can take the following actions to reduce their potential exposure to dangerous air pollutants:

Get informed

- Learn about possible pollution in your area:
  - Visit the U.S. EPA website for information on ozone and particulate levels
  - Contact your state environmental agency or health department for information on local monitoring for other air pollutants
  - Visit NRDC's Don't Get Fracked! Information Center to learn how to protect yourself and your family from pollution linked to hydraulic fracturing
  - For more information on specific oil and gas-related pollutants visit:
    - Benzene
    - Hydrogen sulfide (H_2S)
    - Diesel
    - Other toxics
- If you are worried about health symptoms or impacts, make sure to see your doctor and consult healthcare providers knowledgeable about the health impacts of air pollution. More resources are available through the following organizations:
  - The Pediatric Environmental Health Speciality Units (PEHSU)
  - Association of Environmental Medicine Clinics

Protect the most vulnerable

- Young children, the elderly, and individuals with respiratory conditions (e.g., asthma) can be sensitive to lower levels of pollution and should avoid exercise or extended outdoor activity when odors are present or agency websites (EPA or state) indicate poor air quality.

Take Action

- Improve air quality monitoring in your community
- Report spills and other environmental problems in your community
- Connect with your neighbors and set up a Citizen Science group
- Speak up and organize your community's defense
- Demand stronger protections

APPENDIX

Figure 2: Major air pollutants and air toxics released during the different fracking process stages and sources of equipment

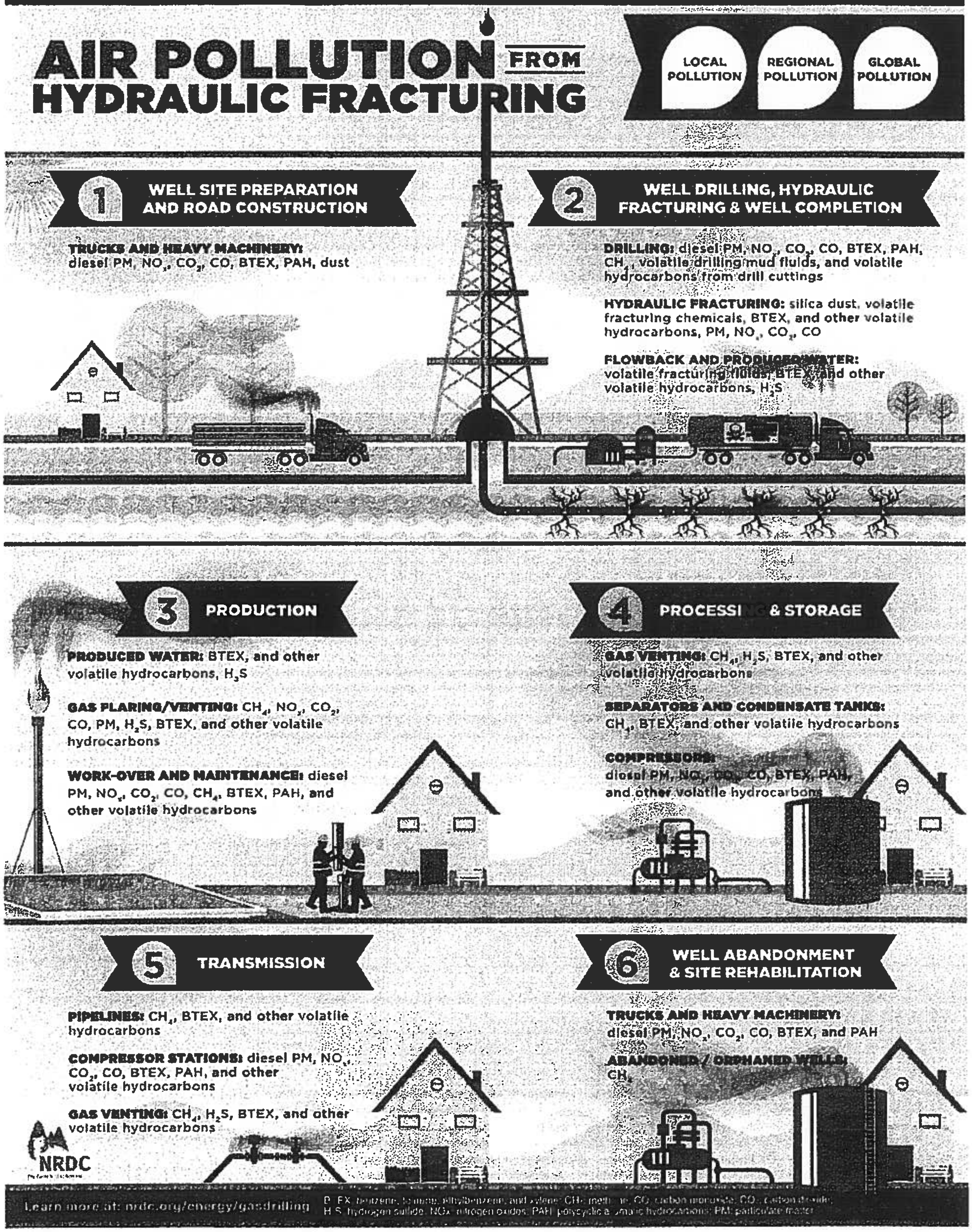

Table 1: Characterization of the main sources of air pollution from oil and gas development according to well process stage											
	Local							Regional		Global	
	Particulate Matter (PM)		Volatile Organic Compounds (VOCs)							Greenhouse Gases	
Emissions Source	Diesel PM	PM_{10}	BTEX	PAH (incl. Naphthalene, Chlorobenzene, Phenol)	Other (incl. Formaldehyde, Ethylene glycol, Methanol)	H_2S	Respirable silica	VOCs	NO_x	CH_4	CO_2
Well site preparation (landscape clearing, soil movement, pipelines and other infrastructure)	•	•	•	•					•		•
Well drilling, hydraulic fracturing and well completion (drill rig, drilling muds and cuttings, fracturing fluid mixing, water trucks, pumps, generators, flowback	•	•	•	•	•	•	•	•	•	•	•
Well production (produced water, gas flaring/ venting, well maintenance work)	•	•	•	•	•	•		•	•	•	•
Processing and storage (gas venting, glycol dehydrators, separators, condensate tanks, compressors)	•	•	•	•	•	•		•	•	•	•
Transmission (compressors, gas venting, pipelines, tanker trucks	•	•	•	•	•			•	•	•	•
Well abandonment & site rehabilitation	•	•	•	•					•	•	•

Sources: Adgate, J., Goldstein, B., and McKenzie, L. 2014. "Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development." *Environmental Science & Technology*, doi: 10.1021/es404621d. Moore, Christopher W. et al. 2014. "Air Impacts of Increased Natural Gas Acquisition, Processing, and Use: A Critical Review." *Environmental Science & Technology*, 11. doi:dx.doi.org/10.1021/es4053472.

Key: BTEX: benzene, toluene, ethylbenzene, xylene; CH_4: methane; CO_2: carbon dioxide; diesel PM: diesel particulate matter; H_2S: hydrogen sulfide; NO_x: nitrogen oxides; O_3: ozone; PAH: polycyclic aromatic hydrocarbons; PM_{10}: particulate matter of 10 micrometers or smaller in diameter.

Table 2: Health impacts of the main air pollutants by target organ and system

Pollutant	Target organ/system	Carcinogen
Particulate Matter (PM)		
Diesel PM	Respiratory system; Cardiovascular system	●
PM_{10} and smaller	Respiratory system; Cardiovascular system	
Volatile Organic Compounds (VOCs)		
Benzene	Immune system; Blood; Fetal development, Nervous System	●
Toluene	Brain and nervous system; Respiratory system; Fetal and child development; Reproductive system	
Ethylbenzene	Fetal and child development; Liver; Kidney; Endocrine system; Auditory system	●
Xylene	Brain and nervous system; Fetal and child development	
Other VOCs (incl. Formaldehyde, Methanol)	Immune system; Respiratory system; Brain and nervous system; Fetal and child development; Liver; Kidney; Endocrine system	●
Other		
Hydrogen sulfide (H_2S)	Respiratory system; Brain and nervous system; Gastrointestinal system	
NO_x	Respiratory system	
Ozone (O_3)	Respiratory system; Cardiovascular system	
Respirable Silica	Respiratory system; Kidneys; Immune system	●
PAHs (incl. Naphthalene)	Immune system*, Reproductive system*; Brain and nervous system*; Developmental effects*	●**

* in animal studies

** probable carcinogens are among the PAHs emitted at unconventional oil & gas sites

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Key: BTEX: benzene, toluene, ethylbenzene, xylene; CH_4: methane; diesel PM: diesel particulate matter; H_2S: hydrogen sulfide; NO_x: nitrogen oxides; O_3: ozone; PAH: polycyclic aromatic hydrocarbons; PM_{10}: particulate matter of 10 micrometers or smaller in diameter.

Endnotes

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Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 03/19/2015 15:15
Provider: Manuel, Mervin MD
Encounter: ACUTE

CHIEF COMPLAINT

The Chief Complaint is: Patient presents today c/o RT wrist/hand pain, x started 2 weeks ago. Denies injury.

HISTORY OF PRESENT ILLNESS

Alexis Elliot is a 11 year old female.
° Medication list reviewed by clinical staff.
° Depression screening not done today.
° No recent hospitalization.

11 yo came in with almost 2 weeks hx of nonspecific right wrist pain it is aggravated by movement. She denies any recent injury but MGM insist its swollen and she had numbing sensation. Also, MGM has mutliple concerns of prior hx of bruising and nose bleeding during the times she was exposed to drilling and ? fracking in their school area. [redacted]

PAST MEDICAL/SURGICAL HISTORY

Other:
No hearing loss

Reported:
Depression screening was not completed.
Medical: Currently wearing eyeglasses. Not wearing contact lenses and not using a hearing aid.
Legal Documents: Health care proxy not in chart.

SOCIAL HISTORY

Diet: Not an unusual diet.
Behavioral: No tobacco use and smoking status: Never smoker.
Alcohol: Not using alcohol.
Drug Use: Not using drugs.
Habits: Seeing a dentist. Not moderately exercising 3+ times a week.
Work: Unemployed.
Marital: Single.
Functional: No severe visual impairment and self-reliant in usual daily activities.

REVIEW OF SYSTEMS

Systemic: No fever and no night sweats.
Gastrointestinal: No anorexia.

Patient:	**194365.0 -** [redacted]
DOB:	**10/29/2003**
SSN:	[redacted]

Date:	**03/19/2015 15:15**
Provider:	**Manuel, Mervin MD**
Encounter:	**ACUTE**

Musculoskeletal: No bone pain.
Skin: No rash.

PHYSICAL FINDINGS

- Vitals taken 03/19/2015 03:06 pm
  meds/alleriges reviewed.CC

BP-Sitting R	132/84 mmHg
BP Cuff Size	Regular
Pulse Rate-Sitting	96 bpm
Pulse Rhythm	Regular
Respiration Rate	20 per min
Height	61 in
Weight	167 lbs 3.2 oz
Body Mass Index	31.6 kg/m2
BMI Percentile	99 %
Body Surface Area	1.75 m2
Oxygen Saturation	97 %

General Appearance:
° Well-appearing. ° Awake. ° Alert. ° Well hydrated. ° In no acute distress.
Abdomen:
Visual Inspection: ° Abdomen was normal on visual inspection.
Palpation: ° Abdomen was soft. ° No abdominal guarding.
Musculoskeletal System:
Wrist:
General/bilateral: ° No swelling of the wrist. ° No induration of the wrist. ° No erythema of the wrist. ° No deformity of the wrists. ° No tenderness on palpation of the wrist.
Right Wrist: • Pain was elicited by motion. • Pain was elicited on flexion.

ASSESSMENT

- Normal Diastolic Blood Pressure of <80
- Normal Systolic Blood Pressure of <130
- Body Mass Index is greater than or equal to 95th percentile for age
- Arthralgia of the right ulna/radius/wrist

VACCINATIONS

- Did not receive dose of influenza virus vaccine patient refused

PLAN

- **ARTHRALGIA - ULNA / RADIUS / WRIST RIGHT**
  Radiology*/X-Ray: XRay-Wrist

Patient: 194365.0 - [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 03/19/2015 15:15
Provider: Manuel, Mervin MD
Encounter: ACUTE

Instructions: right , left for comparison
Lab: CBC DIFF PLATELET
Lab: SEDRATE
Lab: CBC

Discussed with mat GM that her wrist pain maybe musculoskeletal however will do xray to rule out any bony pathology or fracture. WIll do CBC and sedrate to check for any blood dyscrasias and underlying inflammatory cause. WIll discuss further plan once we have results.

Mervin Manuel MD
Electronically signed by: Mervin Manuel, MD Date: 03/19/2015 15:59

Patient: [redacted]
DOB: [redacted]
SSN: [redacted]

Date: 07/30/2013 09:45
Provider: Lybarger, Laura K. CRNP
Encounter: RETURN PATIENT VISIT

SOCIAL HISTORY

Habits: Sleep habits Sleeping location:Bed.
Activities: Activities.

ALLERGIES

- No Known Allergies

FAMILY HISTORY

Cancer Great Grandmother
Heart disease Great Grandmother and Grandfather
Hypertension Great Grandmother and Grandmother
Depression Mother with depression, Father-schizophrenia, bipolar

REVIEW OF SYSTEMS

Systemic: No systemic symptoms.
Head: No head symptoms.
Neck: No neck symptoms.
Eyes: No eye symptoms.
Otolaryngeal: No otolaryngeal symptoms.
Breasts: No breast symptoms.
Cardiovascular: No cardiovascular symptoms.
Pulmonary: No pulmonary symptoms.
Gastrointestinal: No gastrointestinal symptoms.
Genitourinary: No genitourinary symptoms.
Endocrine: No endocrine symptoms.
Hematologic: No hematologic symptoms.
Musculoskeletal: No musculoskeletal symptoms.
Neurological: No neurological symptoms.
Psychological: No psychological symptoms.
Skin: Skin symptoms.

PHYSICAL FINDINGS

- Vitals taken 07/30/2013 09:45 am

Meds and Allergies Reviewed,Amy Jo,CMA

BP-Sitting R	116/70 mmHg	90 - 120/50 - 77
BP Cuff Size	Large	
Pulse Rate-Sitting	80 bpm	55 - 105
Respiration Rate	20 per min	15 - 31
Height	56.25 in	50 - 60
Weight	131 lbs	47 - 104
Body Mass Index	29.1 kg/m2	

Patient: [redacted]
DOB: [redacted]
SSN: [redacted]

Date: 07/30/2013 09:45
Provider: Lybarger, Laura K. CRNP
Encounter: RETURN PATIENT VISIT

BMI Percentile	99 %	
Body Surface Area	1.49 m2	
Oxygen Saturation	99 %	93 - 100

General Appearance:
° Well developed. ° Well nourished. ° In no acute distress.
Lungs:
° Chest was normal to percussion. ° Clear to auscultation.
Cardiovascular:
Heart Rate And Rhythm: ° Normal.
Heart Sounds: ° Normal.
Murmurs: ° No murmurs were heard.
Thrill: ° No thrill.
Arterial Pulses: ° Equal bilaterally and normal.
2 small pink papulces noted to left inner thigh.

ASSESSMENT
- Contact dermatitis

THERAPY
- Clinical summary provided to patient.

PLAN
- **OTHER**
  Lab: OTHER LAB TESTS
  Instructions: burgdorferi antiboidies, lyme titers
  Appts/Follow up Routine: If symptoms worsen or persist.

- Return to the clinic if condition worsens or new symptoms arise

HEALTH REMINDERS
- Heart Exam satisfied 08/10/2013.
- WELL VISIT satisfied 08/10/2013.

Laura K. Lybarger CRNP
Electronically signed by: Laura Lybarger Date: 08/10/2013 08:33

Patient: [redacted]tt
DOB: 10/29/2003
SSN: [redacted]

Date: 06/24/2013 13:45
Provider: Lybarger, Laura K. CRNP
Encounter: ACUTE

COUNSELING/EDUCATION

- Instructions for patient
- Education and counseling
- Patient education about the proper use of medications

PLAN

- **OTHER**
  Appts/Follow up Routine: If symptoms worsen or persist.
  Triamcinolone Acetonide 0.1 % CREA, as directed, 30 days, 0 refills, apply to affected area tid prn
  PredniSONE 10 MG TABS, 1 three times per day, 7 days, 0 refills

- Plan - start medication

--Patient seen by Nurse Practioner (CRNP) & case discussed with Supervising Physician, Dr. Muhly. Plans forumulated in this consultation.
--Antibiotics discussed, including that they can help some infections by acting upon bacteria, but that they cannot act against viruses which cause most infections. Cautioned that antibiotics can sometimes cause serious harm.
--Medications reviewed, discussed & instructions given.
--Diagnostic assessments explained. Discussed potential for later revisions. Explained benefits, risks & alternatives of therapy options.

Continue benadryl prn

HEALTH REMINDERS

- Corticosteroids satisfied 06/24/2013.
- Heart Exam satisfied 07/10/2013.
- WELL VISIT satisfied 07/10/2013.

Laura K. Lybarger CRNP
Electronically signed by: Laura Lybarger Date: 07/10/2013 13:02

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 07/30/2013 09:45
Provider: Lybarger, Laura K. CRNP
Encounter: RETURN PATIENT VISIT

ACTIVE PROBLEMS

- Asthma
- Fatigue
- Overweight
- Polydipsia

CHIEF COMPLAINT

The Chief Complaint is: Pt c/o bulls eye rash 3-4 weeks ago, was told to come back for testing.

HISTORY OF PRESENT ILLNESS

Alexis Elliott is a 9 year old female.
• Medication list reviewed.
° No systemic symptoms.
° No head symptoms.
° No neck symptoms.
° No eye symptoms.
° No otolaryngeal symptoms.
° No breast symptoms.
° No cardiovascular symptoms.
° No pulmonary symptoms.
° No gastrointestinal symptoms.
° No genitourinary symptoms.
° No endocrine symptoms.
° No hematologic symptoms.
• Skin symptoms left innner thigh rash, itchy- everything else has resolved.

Rash has resolved. Still with 2 small lesion on right thigh. Feeling much better.
Did not go to children because rash was resolving
Requesting lyme disease blood work

CURRENT MEDICATION

- PredniSONE 10 MG TABS, 1 three times per day, 7 days, 0 refills
- Triamcinolone Acetonide 0.1 % CREA, as directed, 30 days, 0 refills, apply to affected area tid prn

PAST MEDICAL/SURGICAL HISTORY

Reviewed and unchanged since last visit.

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 06/24/2013 13:45
Provider: Lybarger, Laura K. CRNP
Encounter: ACUTE

ACTIVE PROBLEMS

- Asthma
- Contact Dermatitis
- Fatigue
- Overweight
- Polydipsia

CHIEF COMPLAINT

The Chief Complaint is: Pt presents for red bumps, all over body, x 1 day.

HISTORY OF PRESENT ILLNESS

Alexis Elliott is a 9 year old female.
• Medication list reviewed.
° No systemic symptoms.
° No head symptoms.
° No neck symptoms.
° No eye symptoms.
° No otolaryngeal symptoms.
° No breast symptoms.
° No cardiovascular symptoms.
° No pulmonary symptoms.
° No gastrointestinal symptoms.
° No genitourinary symptoms.
° No endocrine symptoms.
• Skin symptoms rash bilateral arms, legs and face.

Patient was out in the woods. Then went to a beach.
She started breaking out what looked like mosquito bites.
Each day progressively getting bigger and spreading.
Took benadryl yesterday with relief
Itchy
Brother only other person that has similar rash. No other family members

PAST MEDICAL/SURGICAL HISTORY

Reviewed and unchanged since last visit.

SOCIAL HISTORY

Habits: Sleep habits Sleeping location:Bed.
Activities: Activities.

Patient:	[redacted]
DOB:	10/29/2003
SSN:	[redacted]

Date:	**06/24/2013 13:45**
Provider:	**Lybarger, Laura K. CRNP**
Encounter:	**ACUTE**

ALLERGIES

- No Known Allergies

FAMILY HISTORY

Cancer Great Grandmother
Heart disease Great Grandmother and Grandfather
Hypertension Great Grandmother and Grandmother
Depression Mother with depression, Father-schizophrenia, bipolar

REVIEW OF SYSTEMS

Systemic: No systemic symptoms.
Head: No head symptoms.
Neck: No neck symptoms.
Eyes: No eye symptoms and no vision problems.
Otolaryngeal: No otolaryngeal symptoms and no hearing loss.
Breasts: No breast symptoms.
Cardiovascular: No cardiovascular symptoms.
Pulmonary: No pulmonary symptoms.
Gastrointestinal: No gastrointestinal symptoms.
Genitourinary: No genitourinary symptoms.
Endocrine: No endocrine symptoms.
Hematologic: No hematologic symptoms.
Musculoskeletal: No musculoskeletal symptoms.
Neurological: No neurological symptoms.
Psychological: No psychological symptoms.
Skin: Skin symptoms.

PHYSICAL FINDINGS

- Vitals taken 06/24/2013 01:45 pm

Allergies and meds reviewed. J. DeMarino, CMA

BP-Sitting R	102/72 mmHg	90 - 120/50 - 77
BP Cuff Size	Regular	
Pulse Rate-Sitting	79 bpm	55 - 105
Respiration Rate	22 per min	15 - 31
Height	56.25 in	50 - 60
Weight	128 lbs	47 - 104
Body Mass Index	28.4 kg/m2	
BMI Percentile	99 %	
Body Surface Area	1.47 m2	
Oxygen Saturation	98 %	93 - 100

Patient: [redacted]
DOB: [redacted]
SSN: [redacted]

Date: **06/24/2013 13:45**
Provider: **Lybarger, Laura K. CRNP**
Encounter: **ACUTE**

General Appearance:
° Well developed. ° Well nourished. ° In no acute distress.

Neck:
Suppleness: ° Neck demonstrated no decrease in suppleness.
Thyroid: ° Showed no abnormalities.

Eyes:
General/bilateral:
Pupils: ° PERRLA.

Ears:
General/bilateral:
External Auditory Canal: ° External auditory meatus normal.
Tympanic Membrane: ° Normal.

Nose:
General/bilateral:
Discharge: ° No nasal discharge seen.

Pharynx:
Oropharynx: ° Normal.

Lymph Nodes:
° Normal.

Lungs:
° Clear to auscultation.

Cardiovascular:
Heart Rate And Rhythm: ° Normal.
Heart Sounds: ° Normal.
Murmurs: ° No murmurs were heard.
Thrill: ° No thrill.
Carotid Arteries: ° No bruit in the carotid artery.

Abdomen:
Auscultation: ° Bowel sounds were normal.
Palpation: ° No abdominal tenderness.
Liver: ° Not enlarged.
Spleen: ° Not enlarged.

Skin:
° Normal except as noted multple pink papules, blanches. excoriaiton marks noted to bilateral arms, legs and face.

ASSESSMENT

- Contact dermatitis

THERAPY

- Return to the clinic if condition worsens or new symptoms arise.
- Clinical summary provided to patient.

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 04/29/2013 15:30
Provider: Arora, Shweta MD
Encounter: RETURN PATIENT VISIT

ACTIVE PROBLEMS

- Asthma
- Fatigue
- Overweight
- Polydipsia

CHIEF COMPLAINT

The Chief Complaint is: Patient here for ER f/u abdominal pain.

HISTORY OF PRESENT ILLNESS

Alexis Elliott is a 9 year old female.

• Medication list reviewed ° Encounter Background Information: Pt is here for ER follow up abdominal pain which per the mother started about 4 weeks gao- The pt states that teh pai is off and on located in almost teh epigastric region

no fever or chiills
relieved by eating food and tylenol
no worsening factors
+ bloating and flatulence
no sexual concerns
no trauma
no change in BM but initial few days had some BM about 2 times/day
does feel nauseated sometimes but no vomiting
BM today- soft and formed like evryday
no travel or sick contacts
Had U/A done at ER
Mother is upset that the Er didnt do work up

No emotional or school concerns per pt and mother
mother also thinks that she may be beginning her menarche

PAST MEDICAL/SURGICAL HISTORY

Reported:

Surgical / Procedural: No prior surgery.
Physical Trauma: No trauma to the conjunctiva.

Reviewed and unchanged since last visit.

SOCIAL HISTORY

Diet: Nutritious and satisfying diet, diet sufficient in food variety, and sufficient in dairy products.
Behavioral: No tobacco use.

Patient:	[redacted]
DOB:	[redacted]
SSN:	[redacted]

Date:	**04/29/2013 15:30**
Provider:	**Arora, Shweta MD**
Encounter:	**RETURN PATIENT VISIT**

Alcohol: Not using alcohol.
Drug Use: Not using drugs.
Habits: Sleep habits Sleeping location:Bed. Seeing a dentist. Good exercise habits.
Home Environment: Having home safety plans in case of fire.
Activities: Activities.
Marital: No remarkable marital history.

ALLERGIES

- No Known Allergies

FAMILY HISTORY

Cancer Great Grandmother
Heart disease Great Grandmother and Grandfather
Hypertension Great Grandmother and Grandmother
Depression Mother with depression, Father-schizophrenia, bipolar

REVIEW OF SYSTEMS

Systemic: No systemic symptoms, no fever, no chills, and no pain.
Cardiovascular: No chest pain or discomfort, no palpitations, and no pounding heartbeat,no diaphoresis.
Pulmonary: Not feeling congested in the chest, no dyspnea, no paroxysmal nocturnal dyspnea, no orthopnea (orthopnea), and no cough.
Gastrointestinal: Normal appetite. Heartburn sometimes and nausea. No vomiting. Abdominal pain. Bowel movement frequency was normal.
Genitourinary: No genitourinary symptoms, no hematuria, and no change in urinary frequency. No dysuria.
Neurological: No dizziness, no lightheadedness, no fainting, no focal disturbances, no speech difficulties, no difficulty with balance, and no sensory disturbances.

PHYSICAL FINDINGS

- Vitals taken 04/29/2013 03:30 pm
  meds/allergies reviewed JLM

BP-Sitting	110/70 mmHg
Pulse Rate-Sitting	83 bpm
Temp-Tympanic	99.2 F
Height	56 in
Weight	124 lbs
Body Mass Index	27.8 kg/m2
BMI Percentile	99 %
Body Surface Area	1.45 m2
Oxygen Saturation	98 %

Patient: [redacted]
DOB: [redacted]
SSN: [redacted]

Date: 04/29/2013 15:30
Provider: Arora, Shweta MD
Encounter: RETURN PATIENT VISIT

General Appearance:
° Oriented to time, place, and person. ° Well developed. ° In no acute distress. ° Not acutely ill. ° Not poorly hydrated.

Eyes:

General/bilateral:
Extraocular Movements: ° Normal.
Pupils: ° PERRLA.

Lungs:
° Accessory muscles were not used during expiration. ° Normal breath sounds/voice sounds. ° No wheezing was heard. ° No rhonchi were heard. ° No rales/crackles were heard.

Cardiovascular:
Jugular Venous Distention: ° JVD not increased.
Heart Rate And Rhythm: ° Normal.
Heart Sounds: ° Normal.
Murmurs: ° No murmurs were heard.
Edema: ° Not present.

Abdomen:
Visual Inspection: ° Abdomen was not distended.
Auscultation: ° Bowel sounds were normal.
Palpation: ° Abdominal muscle guarding was not demonstrated. ° No abdominal tenderness, no CVAT.
Liver: ° Not enlarged.
Spleen: ° Not enlarged.

Neurological:
° Level of consciousness was normal.
Speech: ° Normal.
Cranial Nerves: ° Normal.

ASSESSMENT
• Abdominal pain possiblepeptic ulcer disease

THERAPY
• • Options were discussed.
• Clinical summary provided to patient.

DISCUSSED
The need for adherence to the regimen.
Explained importance of immunization.

PLAN

Patient: [redacted]
DOB: [redacted]
SSN: [redacted]

Date: 04/29/2013 15:30
Provider: Arora, Shweta MD
Encounter: RETURN PATIENT VISIT

- **OTHER**
  Zantac 15 MG/ML SYRP, as directed, 30 days, 0 refills, 3 tsp po q 12 hrs

- Return to the clinic if condition worsens or new symptoms arise
- Go to the emergency room if condition worsens
- Medication: reviewed; discussed benefits & risks & options; prescriptions issued as listed
- Plan - start medication

--Diagnostic assessments explained. Discussed potential for later revisions. Explained benefits, risks & alternatives of therapy options.
--Medications reviewed, discussed & instructions given.
--Warned patient that there may be an underlying root cause which is not evident today, but which might cause deterioration of health, so you must have further evaluations if these symptoms do not resolve.
Mom advised to call in 2 weeks with info update- mom refuses w/u at thsi time for treatmenet trial
dietary interventions explained
script changed to 10cc po q 12 hrs by verbal to pjharmacy.
--SEE SPECIALIST if problem does not resolve with the treatment prescribed. Offered to set up.

U/A done ate ER neg for Lest and nitrite and no blood

HEALTH REMINDERS

- WELL VISIT satisfied 04/29/2013.

Shweta Arora MD
Electronically signed by: Shweta Arora Date: 04/30/2013 16:20

[redacted] 4/28/2013
9y5
m

☑ Nursing Assessment Reviewed ☑ Vitals Reviewed ______
V/S BP______ HR______ RR______ Temp______

PHYSICAL EXAM

General Appearance __mild / moderate / severe distress
__no acute distress __fussy / crying / cries on exam / irritable
active / playful / smiles __lethargic / weak cry
__attentiveness nml
__good eye contact /
__sleeping/easily aroused

***INFANTS:** __poor consolability / poor intake suck
__nml consolability __poor muscle tone
__nml feeding / suck __closed / bulging / sunken anter. fontanel
__flat anter. fontanel

HEAD / EENT __tenderness / swelling
__conjunct. & lids nml __scleral icterus / injected conjunctivae
__PERRL __EOM palsy / anisocoria / conjunctival exudate
__sunken eyes / photophobia
__ears nml __TM erythema / dullness (R / L)
__loss of TM landmarks (R / L)
__TM obscured by wax (R / L)
__nose nml __rhinorrhea / purulent nasal drainage
__pharynx nml __pharyngeal erythema / tonsillar exudate
__moist mucous membranes __ulcerations / vesicles
__drooling / trismus / mass
__dry mucous membranes

NECK __meningismus / Brudzinski / Kernig's
__supple __lymphadenopathy*
__no masses

RESPIRATORY __respiratory distress
__no resp. distress __retractions / accessory muscle use
__breath sounds nml __prolonged expirations
__decreased air movement / stridor
__grunting (infants) / nasal flaring
__wheezes / rales / rhonchi

CVS __murmur grade ___ /6 sys / dias
__reg. rate & rhythm __peripheral pulses weak / thready
__heart sounds nml __slow cap refill______sec
__strong periph pulses
__nml capillary refill

ABDOMEN (GI) __tenderness / guarding / rebound
__non-tender __hepatomegaly / splenomegaly / mass
__no distention __abnml bowel sounds*
__no organomegaly __NABS
__nml bowel sounds*

GENITALIA __discharge / erythema / swelling / tenderness
__nml inspection __testes undescended
__circumcised (male) __hernia
__uncircumcised (male)

EXTREMITIES (MS) __tenderness
__non-tender
__nml ROM*

SKIN __cyanosis / diaphoresis / pallor / icterus
__no rash / lesions __poor skin turgor
__no petechiae __diaper rash / skin rash
__nml color *urticarial eczematous impetiginous varicelliform*
__warm, dry *scarlatiniform monilial erythematous vesicular crusted*
__skin lesions

NEURO __facial asymmetry
__motor nml __sensory loss / weakness
__sensation nml __unable to assess orientation
__CN's nml as tested
__neuro at baseline

Underline *indicates organ system*
* *equivalent or minimum required for organ system exam*

LABS & XRAYS

CBC *normal except*
WBC______
Hgb______
Hct______
Platelets______
segs______
bands______
lymphs______

Chemistries *normal except*
Na______
K______
Cl______
CO2______
Gluc______
BUN______
Creat______

CRP______
RSV______
Rotavirus______
Flu Screen______
Strep Screen______
Mono Spot______

UA *normal except*
______

Cultures sent
blood x______
urine______

CXR ☐ Interp. by me ☐ Reviewed by me ☐ Discsd w/radiologist
__nml / NAD __no infiltrates __nml heart size __nml lung inflation bilat.

Other ______

Pulse Ox ___% on RA / ___ L O_2 *Interp:* nml / hypoxic Time:______

PROCEDURES

☐ Time out performed

LP __discussed risks, benefits, alternatives; parent/guardian consents.
Time:______ fluid color______ RBC______ WBC______
betadine prep glucose______ polys______ lymph______
L3-4 L4-5 protein______ monos______ gm stn______

PROGRESS

Time______ unchanged improved re-examined

__able to take food / fluid in emergency department
♦ Asthma – *bronchodilator tx / steroid(s)*
__Discussed with Dr.______ Time:______
will see patient in: ED / hospital / office
__Counseled patient / family regarding: Additional history from:
lab / rad. results diagnosis need for follow-up *family caretaker paramedics*
__Rx given
__Smoking Cessation: *discussed: plan / trigger / challenges / gave Rx time:___min*
CRIT CARE TIME *(excluding separately billable procedures)*
30-74 min 75-104 min ___ min

CLINICAL IMPRESSION

Dehydration
Fever
Vomiting / Diarrhea
♦ Asthma / Reactive Airway Disease
acute exacerb. status asthmaticus
Bronchitis / Bronchiolitis - *RSV*
Croup
Gastroenteritis / Enteritis
Hypoxemia
Ingestion
Meningitis
Otitis Media - R / L
Pharyngitis - *Strep / Mono*
Pneumonia
Sepsis
Sinusitis
Upper Respiratory Infection
Urinary Tract Infection
Viral Syndrome / Influenza

Abdominal pain

DISPOSITION- ☑ home ☐ transferred______
Time______ ☐ admitted POA______
CONDITION- ☑ unchanged ☐ improved ☑ stable
Care transferred to Dr.______ Time:______

*RESIDENT / PA / NP-*______ *RTI #*______

ATTENDING NOTE: *Please see resident / MLP note for details*
Resident/PA/NP's history reviewed. Patient interviewed and examined by me.
HPI:______
My personal exam reveals:______
__I agree with assessment and care plan, and confirm the diagnosis(es) above. With exception of______

PHYSICIAN SIGNATURE- [signature] *RTI #*______
☐ Template Complete ☑ See Addendum (Dictated / Template #______)

♦ Quality Measure Initiative

[redacted]
4/28/2013
9y5
m

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14 THE WASHINGTON HOSPITAL
Washington, PA 15301
EMERGENCY PHYSICIAN RECORD
◆Pediatric Illness◆

DATE 4/28/13 TIME SEEN 23:50 ☐ on arrival
ROOM 14 __EMS Arrival __EMS treatments ordered
HISTORIAN mother father patient paramedics
AGE 9 M / F RACE
__HX / __EXAM LIMITED BY:

HPI

chief complaint: fever cough / congested fussy pulling ears not eating less active vomiting diarrhea rash ingestion
Nausea

onset / duration: 4 wks hrs / days ago

timing: continues in ED gone now / better intermittent / worse

context:
Stomach cramps
Today came Home from ... wants to sleep

severity: mild moderate severe (/10)

associated symptoms / ROS: Crying / Exhausted

GENERAL
fever ___ °F / °C R O T Ax
subjective persistent
HEENT
red eyes / discharge
earache / pulling at ears
runny nose / congestion
colored / clear drainage
sore throat
RESP
cough
with vomiting
trouble breathing
wheezing stridor
mild moderate severe
GI
vomiting x
bilious bloody
diarrhea x
bloody stools
abdominal pain
drinking / eating less
LNMP ___ preg premenstrual

GU
decreased urination
pain with urination
NEURO
acting differently
fussy crying more inconsolable
not sleeping decreased activity
headache
seizure
generalized focal
duration:
incontinent / postictal confusion
SKIN
skin rash
facial trunk extremities diffuse
diaper rash
MS / LYMPH
extremity pain / swelling
lumps / swollen glands

☑ all systems neg. except as marked

Tried Tylenol / Motrin

sick contacts home school other

Similar symptoms previously

Recently seen / treated by doctor / hospitalized

PAST HX

Birth HX birth wt
complications at birth
premature birth ___ wks
C-section / vaginal delivery
Birth wt

diabetes Type I insulin
ear infection(s)
febrile seizure
pharyngitis
pneumonia
seizure disorder
sickle cell disease
urinary tract infection(s)
VP shunt

asthma
bronchitis / bronchiolitis
cardiac problems
congenital heart disease
developmental delay

__old records ordered / summary:
Healthy

Immunizations UTD / referred to PCP

Medications __none see nurses note
aspirin ibuprofen acetaminophen
last dose

Allergies __NKDA
see nurses note

SOCIAL HX
smoker / 2nd hand exposure
alcohol (recent / heavy / occasional) drugs
attends daycare / school 3rd grade caretaker / foster care

FAMILY HX
__negative adopted
Cancers / CAD / HTN
Lung Disease

Page 1 of 2

MAY 0 2 2013

KT [redacted] 4/28/2013 9y5 m KT KT

(M)

13 0014 The Washington Hospital
Washington, Pa 15301
EMERGENCY NURSING RECORD
Pediatric Illness

ARRIVAL TIME 2205 TRIAGE TIME 2245
ESI TRIAGE LEVEL: 1 2 3 4 5

D.O.B: AGE: 9 M F
HISTORIAN: parent patient EMS family
PCP: SPECIALIST
BARRIERS: learning communication interpreter
ARRIVAL MODE: car EMS police W/C AMB
IMMUNIZATIONS: tetanus ___ years UTD
flu pneumovax

TREATMENT PTA see EMS report IV O_2 tylenol ibuprofen
Time of last dose amount given
last blood glucose mg/dL

VITALS Weight 62.5
BP 130/71 P 80 RR 20 Temp 98.1 F temporal O R
Less than 24 mo: Lgth in Head Cir cm
SpO_2 98 % RA / L O_2 via NC / mask

PAIN LEVEL (1/10) current: 6/10 max /10 acceptable /10

CHIEF COMPLAINT started ___ min / hrs / days ago
Mid to Right Abd pain
x 2 weeks > diarrhea x 2 days

fever — trouble breathing
earache / pulling at ears R / L — nausea / vomiting x
runny nose — diarrhea
sore throat / cough — # of wet diapers
red eyes / discharge R / L — change in appetite
foreign body nose ear R / L — abd pain
chemical / CO exposure — rash
ingestion — seizure
listless

ALLERGIES NKDA
PCN / ASA / sulfa / codeine / iodine / latex

MEDS none see med list

PAST MEDICAL HX

LNMP pregnant / premenstrual

SOCIAL HX
smoking in house NO
attends daycare / school

SCREENINGS
Infectious disease risk hepatitis / HIV / TB exposure / symptoms
Do you feel safe in your environment? feels safe does not feel safe
unable to evaluate see note
SUICIDE RISK ASSESSMENT Sad Persons scale
FALL RISK ASSESSMENT Score
ADVANCE DIRECTIVE __ YES __ NO

TIME TO ROOM 2230 ROOM: 14

PRIMARY ASSESSMENT TIME
✓ Airway patent — compromised
✓ Breathing unlabored — labored / respiratory distress
✓ Circulation nml — pale / diaphoretic
✓ neuro awake alert — listless / memory loss
— crying / fussy / inconsolable

SECONDARY ASSESSMENT
NEURO
✓ oriented x 4 — disoriented to person place time situation
✓ PERRL — pupils unequal R L
✓ maintains eye contact — lack of eye contact

HEENT
✓ nml inspection — fontanel bulging / sunken
✓ nml eye inspection — red conjunctivae / exudate
✓ nml mucous membranes — drainage nasal ear
— drooling
— dry mucous membranes

CHEST
✓ nml breath sounds — wheezing / rales / stridor / grunting
— nasal flaring / retractions

CVS
✓ regular rate — tachycardia / bradycardia
✓ pulses strong / equal — pulse deficit
✓ cap refill less than 2 sec — cap refill greater than 2 sec

ABDOMEN / GU
— Right and Abd
nml inspection — tenderness / guarding / rebound
~~soft, non-tender~~ — ~~firm / distended~~
bowel sounds nml — bowel sounds hyper hypo absent
— catheter present

EXTREMITIES
✓ non-tender — tenderness
✓ moves all extremities — limited ROM

SKIN
✓ warm, dry — cool / cyanotic
✓ intact — skin / diaper rash
✓ no rash — poor skin turgor
✓ turgor good

FUNCTIONAL / NUTRITIONAL ASSESSMENT
✓ development - age appropriate — obese / malnourished
✓ appears well nourished / hydrated — recent weight loss / gain
LIFT STATUS ✓ no lift — sit to stand — Viking — total lift
SLING SIZE — small — medium — large — extra large
ADDITIONAL FINDINGS

INITIAL ACTIONS

TIME			INIT
2245	ID / allergy band	applied / verified	TS
	disrobed / gowned	blanket provided	
	bed low position	side rails up x1 x2	
	call light in reach	head of bed elevated	
	~~held by parent~~	caregiver	
✓	Falls Risk:	ED vocera alert falling star clip-on alarm	

Primary Nurse Signature

RN Signature

*Wong-Baker FACES Pain Rating Scale Copyrighted by Mosby, Inc. Reprinted by permission.

Circle positives, backslash negatives, check √ normals

♦ Regulatory Measure

KT

[redacted] 4/28/2013
9y5 m

ACTIONS

TIME		INIT
	agency notified	
	cardiac monitor	
	pulse oximeter______% RA/______L	
	O_2 ____L via NC / venti / NRB / BVM blow-by	
	bedside glucose______mg/dL	
	ready for provider eval / notified provider	
	restraints see documentation	
	hourly rounding safety rounding	
	smart toileting safety sitter	

IV STARTS

TIME	#	site	Ga	attempts	comments	INIT

IV / MEDICATION INFUSION RECORD

Start Date/Time	Solution / Med	Type	Rate ml / hr	Stop Time	Amount Infused	INIT
	Response: no change improved					

MEDICATIONS

Date/Time	Medication	Dose	Route	Site	INIT
	DTaP / Tdap / DT / Td / TIG	0.5mL	IM		
	lot #: exp. date manufac				
	Response: no change improved pain __/10				

PROCEDURES

TIME		INIT
	portable / to Xray w/ monitor / nurse / O_2 / tech	
	return to room	
	to CT w/ monitor / nurse / O_2 / tech / escort	
	return to room	
	lab drawn / sent by ED tech / nurse / lab	
	LP tray set up	
	consent signed	
	assisted with LP / tolerated well	
	spinal fluid to lab	
	bronchodilator treatment nebulizer inhaler	
	x 1	
	x 2	
	x 3	
	Foley / straight cath see continuation sheet for details	
	urine collection bag placed	
	UA obtained / sent	

VITAL SIGNS

TIME	BP	P	RR	T	SpO_2	Rhythm	Pain	INIT
							/10	
							/10	
							/10	

PAIN REASSESSMENT

Time	Quality	Location	Level	INIT
			/10	
			/10	
			/10	

RESPIRATORY REASSESSMENT

TIME					
Pulse Ox					
Respiratory Rate					
Pulse					
Breath Sounds					
Peak Flow					
INIT					

ADDITIONAL NOTES

INTAKE__________ OUTPUT__________

__IV / lock discontinued: cath intact no swelling no redness______

Time______ INIT______ __IV / lock to floor: amount remaining______

PROPERTY TO: patient family security safe see patient belongings list

Discharge Vitals: BP________ P______ RR______ T______°F
pain level ___/10 SpO_2______ GCS______ Time______

CONDITION

__unchanged __improved ✓ stable __other______

DISPOSITION

✓ discharged home daycare police medical examiner funeral home

✓ verbal / written instructions / RX given to: parent ______

✓ verbalized understanding

✓ accompanied by / driver______

__social service / referral______

__notified family / police / medical examiner______

__admitted / transferred to______

__report to______ time______

__transfer documentation completed see transfer of care template

__left AMA / LWBS signed AMA sheet refused ______

__physician notified:______

__CYS notification______

__HIPAA disclosure log completed Y / N

Mode: walk crutches W/C stretcher ambulance w / monitor w / RN w / escort

Depart Date 4/29/13 Time 0014 am / pm

Discharge Nurse Signature [signature]

☐ Continuation Sheet

SIGNATURE	INITIAL
[signature]	[initials]

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 03/11/2013 14:30
Provider: Clemons, Linda L. CRNP
Encounter: ACUTE

CHIEF COMPLAINT

The Chief Complaint is: Acute; Patient here with fevers, headaches, cough. Patient was seen last week, she is not getting any better.

REASON FOR VISIT

Visit for: examination.

HISTORY OF PRESENT ILLNESS

Alexis Elliott is a 9 year old female. Source of patient information was patient.
° No constant generalized pain ° Not feeling tired (fatigue) ° No fever ° No chills
° No localized soft tissue swelling in both legs ° Not in both feet
° Mood was euthymic ° Not thinking about suicide

REVIEW OF SYSTEMS

Head: Headache.
Neck: No neck pain, no neck stiffness, and no lump or swelling in the neck.
Otolaryngeal: No nasal discharge and no sore throat.
Cardiovascular: No chest pain or discomfort, no palpitations, the heart rate was not slow, and the heart rate was not fast.
Pulmonary: Feeling congested in the chest. No dyspnea. Cough. No wheezing.
Psychological: No anxiety and no depression.

PHYSICAL FINDINGS

• Vitals taken 03/11/2013 02:30 pm

GE McDonald		
BP-Sitting R	90/60 mmHg	90 - 120/50 - 77
BP Cuff Size	Regular	
Pulse Rate-Sitting	75 bpm	55 - 105
Temp-Oral	98.2 F	96 - 101
Height	56 in	50 - 60
Weight	123 lbs	47 - 104
Body Mass Index	27.6 kg/m2	
BMI Percentile	99 %	
Body Surface Area	1.44 m2	
Pain Level	1	
Pain Level Note	Denies pain	
Oxygen Saturation	98 %	93 - 100

General Appearance:
° Well-appearing. ° Well developed. ° Well nourished. ° Active. ° In no acute distress.

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 03/11/2013 14:30
Provider: Clemons, Linda L. CRNP
Encounter: ACUTE

Ears:
General/bilateral:
Tympanic Membrane: ° Normal.
Hearing: ° No hearing loss noted.
Nose:
General/bilateral:
Discharge: ° No nasal discharge seen.
External Deformities: ° No external nose deformities.
Cavity: ° Nasal septum not deviated. ° Nasal turbinate not swollen.
Sinus Tenderness: ° No sinus tenderness.
Pharynx:
Oropharynx: ° Normal. ° Tonsils showed no abnormalities.
Lymph Nodes:
° Submandibular lymph nodes were not enlarged.
Lungs:
° Normal breath sounds/voice sounds. ° No wheezing was heard. ° No rhonchi were heard. ° No rales/crackles were heard.
Cardiovascular:
Heart Rate And Rhythm: ° Normal. ° No bradycardia present. ° No tachycardia present.
Heart Sounds: ° Normal.
Murmurs: ° No murmurs were heard.
Edema: ° Not present.
Musculoskeletal System:
Foot:
General/bilateral: ° No swelling of the feet.
Psychiatric:
Appearance: ° Normal.
Demonstrated Behavior: ° Behavior demonstrated no abnormalities.
Attitude: ° Not abnormal.
Mood: ° Euthymic.
Affect: ° Normal.

ASSESSMENT
• Upper respiratory infection

THERAPY
• Clinical summary provided to patient.

PLAN
- **UPPER RESPIRATORY INFECTION**
  Benzonatate 200 MG CAPS, 1 three times per day, 30 days, 1 refills

Patient: [redacted]
DOB: [redacted]
SSN: [redacted]

Date: 03/11/2013 14:30
Provider: Clemons, Linda L. CRNP
Encounter: ACUTE

• Instructions for patient -- Increase fluid intake (fluids help loosen secretions; warm fluids can increase rate of mucus flow)
Rest as much as possible
Reinforced good hygiene, frequent hand-washing
Avoid respiratory irritants ? smoke, strong odors, extremely cold temperatures
Monitor for signs of worsening infection ? increase in fever, increase in cough, increase in mucous.
May use OTC cough suppressants only if cough interferes with sleep
Antihistamines are ineffective
Guaifenesin provide NO benefit
Saline nasal spray 2-3 drops 2-3 times a day
• Return to the clinic if condition worsens or new symptoms arise
• Go to the emergency room if condition worsens

Linda L. Clemons CRNP
Electronically signed by: Linda Clemons Date: 03/11/2013 14:27

Patient: [redacted]
DOB: [redacted]
SSN: [redacted]

Date: 03/05/2013 13:30
Provider: Clemons, Linda L. CRNP
Encounter: ACUTE

REVIEW OF SYSTEMS

Head: No headache, no facial pain, and no sinus pain.
Neck: No neck pain, no neck stiffness, and no lump or swelling in the neck.
Otolaryngeal: No earache and no tinnitus. Nasal discharge green nasal drainage. No sore throat.
Cardiovascular: No chest pain or discomfort, no palpitations, the heart rate was not slow, and the heart rate was not fast.
Pulmonary: Not feeling congested in the chest and no dyspnea. Cough nonproductive. Not coughing up sputum and no wheezing.
Neurological: No dizziness.
Psychological: No anxiety and no depression.

PHYSICAL FINDINGS

- Vitals taken 03/05/2013 01:30 pm

Allergies and meds reviewed. J. DeMarino, CMA

BP-Sitting L	106/66 mmHg	90 - 120/50 - 77
BP Cuff Size	Regular	
Pulse Rate-Sitting	100 bpm	55 - 105
Temp-Tympanic	98 F	96 - 101
Height	56.5 in	50 - 60
Weight	124 lbs	47 - 104
Body Mass Index	27.3 kg/m2	
BMI Percentile	99 %	
Body Surface Area	1.46 m2	
Oxygen Saturation	100 %	93 - 100

General Appearance:
° Well-appearing. ° Well developed. ° Well nourished. ° Active. ° In no acute distress.

Ears:
General/bilateral:
External Auditory Canal: ° External auditory meatus normal.
Tympanic Membrane: ° Normal.
Hearing: ° No hearing loss noted.

Nose:
General/bilateral:
Discharge: ° No nasal discharge seen.
External Deformities: ° No external nose deformities.
Cavity: • Nasal turbinate swollen. ° Nasal septum not deviated.
Sinus Tenderness: ° No sinus tenderness.

Pharynx:
Oropharynx: ° Normal. ° Tonsils showed no abnormalities.

Lymph Nodes:
° Submandibular lymph nodes were not enlarged.

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 03/05/2013 13:30
Provider: Clemons, Linda L. CRNP
Encounter: ACUTE

Lungs:
° Normal breath sounds/voice sounds. ° No wheezing was heard. ° No rhonchi were heard. ° No rales/crackles were heard.

Cardiovascular:
Heart Rate And Rhythm: ° Normal. ° No bradycardia present. ° No tachycardia present.
Heart Sounds: ° Normal.
Murmurs: ° No murmurs were heard.

Psychiatric:
Appearance: ° Normal.
Demonstrated Behavior: ° Behavior demonstrated no abnormalities.
Attitude: ° Not abnormal.
Mood: ° Euthymic.
Affect: ° Normal.

ASSESSMENT

• Upper respiratory infection

THERAPY

• Clinical summary provided to patient.

PLAN

• **UPPER RESPIRATORY INFECTION**
Benzonatate 100 MG CAPS, 1 three times per day, 30 days, 1 refills

• Instructions for patient -- Increase fluid intake (fluids help loosen secretions; warm fluids can increase rate of mucus flow)
Rest as much as possible
Reinforced good hygiene, frequent hand-washing
Avoid respiratory irritants ? smoke, strong odors, extremely cold temperatures
Monitor for signs of worsening infection ? increase in fever, increase in cough, increase in mucous.
May use OTC cough suppressants only if cough interferes with sleep
Antihistamines are ineffective
Guaifenesin provide NO benefit
Saline nasal spray 2-3 drops 2-3 times a day
• Return to the clinic if condition worsens or new symptoms arise
• Go to the emergency room if condition worsens

HEALTH REMINDERS

• Dyspnea satisfied 03/05/2013.
• Assess Daytime and Nighttime Symptoms satisfied 03/05/2013.

Patient:	[redacted]
DOB:	10/29/2003
SSN:	[redacted]

Date:	**03/05/2013 13:30**
Provider:	**Clemons, Linda L. CRNP**
Encounter:	**ACUTE**

- Heart Exam satisfied 03/05/2013.
- Physical Activity Tolerance satisfied 03/05/2013.
- WELL VISIT satisfied 03/05/2013.

Linda L. Clemons CRNP
Electronically signed by: Linda Clemons   Date: 03/05/2013 13:30

Patient: [redacted]
DOB: [redacted]
SSN: [redacted]

Date: 08/10/2012 13:00
Provider: CEPEDA, KARLA B. M.D.
Encounter: RETURN PATIENT VISIT

ASSESSMENT

- Normal routine history and physical well-child (6 - 12)
- Asthma
- Overweight

ACTIVE PROBLEMS

- Asthma
- Fatigue
- Overweight
- POLYDIPSIA

THERAPY

- Review of immunization history.
- No need for prophylactic fluoride administration.
- Clinical summary provided to patient.

COUNSELING/EDUCATION

- Anticipatory guidance: meet with teachers; get involved with school
- Anticipatory guidance: limit computer andvideo time
- Anticipatory guidance: play with child
- Discussed safety practices: neighborhood safety
- Discussed use of restraints: use belt positioning booster seat in back seat
- Discussed use of smoke detectors
- Discussed precautions against drowning
- Discussed stranger safety
- Discussed street crossing: teach pedestrian safety
- Discussed bicycle safety
- Discussed sports safety
- Discussed concerns about exercise: promote physical activity
- Discussed concerns about dental hygiene: schedule dental appointment
- Discussed concerns about bedtime
- Discussed household chores

PLAN

--Diet advised. Rx diet, low fat, low in carbs, using small portions & not skipping meals. Include daily whole grains & vegetables & fruit. Avoid snacks and junk food. Three meals each day. Increase metabolism & fitness by 30 minutes daily activity.

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 08/10/2012 13:00
Provider: CEPEDA, KARLA B. M.D.
Encounter: RETURN PATIENT VISIT

HEALTH REMINDERS

- WELL VISIT satisfied 08/10/2012.

KARLA B. CEPEDA M.D.
Electronically signed by: Karla Cepeda Date: 08/10/2012 13:37

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 03/05/2013 13:30
Provider: Clemons, Linda L. CRNP
Encounter: ACUTE

ACTIVE PROBLEMS

- Asthma
- Fatigue
- Overweight
- Polydipsia

CHIEF COMPLAINT

The Chief Complaint is: Pt presents for "barking" cough and nasal drainage, x 2-3 days.

REASON FOR VISIT

Visit for: examination.

HISTORY OF PRESENT ILLNESS

Alexis Elliott is a 9 year old female. Source of patient information was patient • Medication list reviewed

° Mood was euthymic

CURRENT MEDICATION

- None

PAST MEDICAL/SURGICAL HISTORY

Reviewed and unchanged since last visit.

SOCIAL HISTORY

Habits: Sleep habits Sleeping location:Bed.
Activities: Activities.

ALLERGIES

- No Known Allergies

FAMILY HISTORY

Cancer Great Grandmother
Heart disease Great Grandmother and Grandfather
Hypertension Great Grandmother and Grandmother
Depression Mother with depression, Father-schizophrenia, bipolar

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 08/10/2012 13:00
Provider: CEPEDA, KARLA B. M.D.
Encounter: RETURN PATIENT VISIT

SUBJECTIVE
Parent responds normally.
Normal parent/child communication: verbal and nonverbal.

CHIEF COMPLAINT
The Chief Complaint is: Pt presents for 8 year well child.
Pt needs physical for school.

REASON FOR VISIT
Visit for: 7-10 year visit.

HISTORY OF PRESENT ILLNESS
ALEXIS ELLIOTT is an 8 year old female.
She reported: Medication list reviewed.
Recent weight gain, grandma spoils her and does not control her food intake.
Bowel movement frequency was normal. Softly formed stools.
Urinary symptoms: urination normal. No changes in urinary habits.
No middle-night awakening, no initiation of menses.

CURRENT MEDICATION
- None

ALLERGIES
- No Known Allergies

PAST MEDICAL/SURGICAL HISTORY
Reviewed and unchanged since last visit.

SOCIAL HISTORY
Diet: Nutritious and satisfying diet, diet sufficient in food variety, and sufficient in dairy products.
Habits: Sleep habits Sleeping location:Bed. Seeing a dentist. Good exercise habits.
Home Environment: Having home safety plans in case of fire.
Activities: Activities.

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 08/10/2012 13:00
Provider: CEPEDA, KARLA B. M.D.
Encounter: RETURN PATIENT VISIT

FAMILY HISTORY

Cancer Great Grandmother
Heart disease Great Grandmother and Grandfather
Hypertension Great Grandmother and Grandmother
Depression Mother with depression, Father-schizophrenia, bipolar

REVIEW OF SYSTEMS

Systemic: No systemic symptoms.
Neck: No neck symptoms.
Eyes: No eye symptoms.
Otolaryngeal: No otolaryngeal symptoms.
Cardiovascular: No cardiovascular symptoms.
Pulmonary: No pulmonary symptoms.
Gastrointestinal: No gastrointestinal symptoms.
Genitourinary: No genitourinary symptoms.
Musculoskeletal: No musculoskeletal symptoms.
Neurological: No neurological symptoms.
Psychological: No psychological symptoms and good school performance. No interpersonal relationship problems.
Skin: No skin symptoms.

PHYSICAL FINDINGS

- Vitals taken 08/10/2012 01:00 pm
  Allergies and meds reviewed. J. Riddle, CMA

BP-Sitting L	104/84 mmHg
BP Cuff Size	Regular
Pulse Rate-Sitting	101 bpm
Respiration Rate	18 per min
Height	54.25 in
Weight	114 lbs 3.2 oz
Body Mass Index	27.3 kg/m2
BMI Percentile	99 %
Body Surface Area	1.37 m2
Oxygen Saturation	98 %

Standard Measurements:
The patient was overweight.
General Appearance:
Well-appearing, oriented to time, place, and person, well developed, well nourished, well hydrated, and in no acute distress.
Head:
Injuries: No evidence of a head injury.
Appearance: Head normocephalic.

Patient: [redacted]TT
DOB: 10/29/2003
SSN: [redacted]

Date: 08/10/2012 13:00
Provider: CEPEDA, KARLA B. M.D.
Encounter: RETURN PATIENT VISIT

Neck:
Suppleness: The neck demonstrated no decrease in suppleness.
Cervical Mass: No cervical mass was seen.

Eyes:
General/bilateral:
Pupils: PERRLA.
External: The external eye showed no abnormalities.

Ears:
General/bilateral:
External Auditory Canal: External auditory meatus normal.
Tympanic Membrane: Tympanic membrane normal.
Hearing: No hearing loss noted.

Nose:
General/bilateral:
Discharge: No nasal discharge seen.
External Deformities: No external nose deformities.

Pharynx:
Oropharynx: The oropharynx was normal.

Lymph Nodes:
Lymph nodes: normal.

Lungs:
The respiratory excursion was not diminished. Lungs clear to auscultation.

Cardiovascular:
Heart Rate And Rhythm: Heart rate and rhythm normal.
Heart Sounds: Heart sounds normal.
Murmurs: No murmurs were heard.

Abdomen:
Auscultation: The bowel sounds were normal.
Palpation: No abdominal tenderness and no abdominal mass was palpated.
Liver: The liver was not enlarged.
Spleen: The spleen was not enlarged.
Hernia: No hernia was discovered.

Neurological:
Speech: The speech was normal.
Cranial Nerves: The cranial nerves were normal.
Motor: A motor exam demonstrated no dysfunction.
Gait And Stance: Gait and stance were normal.
Reflexes: Normal right knee jerk reflex and of the left knee was normal.

Skin:
The skin was normal.

Growth And Development:
Normal 6-11 year milestones, shows appropriate behavior at home, shows appropriate behavior at school, shows appropriate behavior when playing with friends, can read and do math at grade level, shows pride in achievements, can talk about what goes on in school, and completes school work.

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 05/21/2012 10:05
Provider: HOLT, DANIEL L. MD
Encounter: RETURN PATIENT VISIT

ACTIVE PROBLEMS

- Fatigue
- POLYDIPSIA

CHIEF COMPLAINT

The Chief Complaint is: Excessive bruising on legs and arms
x 4 days ago.

HISTORY OF PRESENT ILLNESS

ALEXIS ELLIOTT is an 8 year old female.
° No photophobia.

Has had bruising on arms and legs and increase thirst and urinating

PAST MEDICAL/SURGICAL HISTORY

Reported:
Surgical / Procedural: No prior surgery.
Physical Trauma: No trauma to the conjunctiva.

SOCIAL HISTORY

Diet: Nutritious and satisfying diet, diet sufficient in food variety, and sufficient in dairy products.
Behavioral: No tobacco use.
Alcohol: Not using alcohol.
Drug Use: Not using drugs.
Habits: Sleep habits Sleeping location:Bed. Seeing a dentist. Good exercise habits.
Home Environment: Having home safety plans in case of fire.
Activities: Activities.
Marital: No remarkable marital history.

ALLERGIES

- No Known Allergies

FAMILY HISTORY

Cancer Great Grandmother
Heart disease Great Grandmother and Grandfather
Hypertension Great Grandmother and Grandmother
Depression Mother with depression, Father-schizophrenia, bipolar

PHYSICAL FINDINGS

- Vitals taken 05/21/2012 10:05 am

Patient: [redacted]
DOB: [redacted]
SSN: [redacted]

Date: 05/21/2012 10:05
Provider: HOLT, DANIEL L. MD
Encounter: RETURN PATIENT VISIT

meds/allergies reviewed NEB

BP-Sitting	100/60 mmHg	90 - 120/50 - 77
BP Cuff Size	Regular	
Pulse Rate-Sitting	89 bpm	55 - 105
Respiration Rate	20 per min	15 - 31
Height	53 in	48 - 57
Weight	112 lbs 12.8 oz	42 - 89
Body Mass Index	28.2 kg/m2	
BMI Percentile	99 %	
Body Surface Area	1.34 m2	
Oxygen Saturation	99 %	93 - 100

General Appearance:
° Well developed. ° Well nourished. ° In no acute distress.

Neck:
Suppleness: ° Neck demonstrated no decrease in suppleness.
Thyroid: ° Showed no abnormalities.
Cervical Mass: ° No cervical mass was seen.

Pharynx:
Oropharynx: ° Normal.

Lymph Nodes:
° Normal.

Lungs:
° Normal breath sounds/voice sounds. ° No wheezing was heard. ° No rhonchi were heard. ° No rales/crackles were heard.

Cardiovascular:
Heart Rate And Rhythm: ° Normal.
Heart Sounds: ° Normal.
Murmurs: ° No murmurs were heard.

Abdomen:
Visual Inspection: ° Abdomen was not distended.
Auscultation: ° Bowel sounds were normal.
Palpation: ° Abdominal muscle guarding was not demonstrated. ° No abdominal tenderness. ° No mass was palpated in the abdomen.
Liver: ° Not enlarged.

Skin:
• Showed ecchymosis. • Ecchymosis on both upper arms. • Ecchymosis on both legs.

TESTS

Fingerstick Blood Sugar -- 82

ASSESSMENT

- Polydipsia
- A tendency for easy bruising
- Fatigue

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 05/21/2012 10:05
Provider: HOLT, DANIEL L. MD
Encounter: RETURN PATIENT VISIT

PLAN

- **FATIGUE**
  Lab: CBC DIFF PLATELET
  Lab: TSH
  Lab: COMPREHENSIVE SCREEN
  Lab: PT/INR

- **OTHER**
  IN OFFICE PROCEDURES
  GLUCOMETER
  FollowUp Routine Apt
  Follow up if symptoms worsen or persist

- Warm compresses

DANIEL L. HOLT MD
Electronically signed by: Daniel Holt Date: 06/06/2012 22:38

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 11/23/2011 14:15
Provider: SKIFFINGTON MD., EUGENE W.
Encounter: RETURN PATIENT VISIT

CHIEF COMPLAINT
The Chief Complaint is: Pt c/o eyes being pink and pt states where matted shut this morning X 1 day.

HISTORY OF PRESENT ILLNESS
ALEXIS ELLIOTT is an 8 year old female.
• Itching of the eyes • Gritty eyes • Watery discharge from eyes • Mucous discharge from the eyes • Red eyes ° No eye pain ° No photophobia

PAST MEDICAL/SURGICAL HISTORY
Reported:
Surgical / Procedural: No prior surgery.
Physical Trauma: No trauma to the conjunctiva.

SOCIAL HISTORY
Diet: Nutritious and satisfying diet, diet sufficient in food variety, and sufficient in dairy products.
Behavioral: No tobacco use.
Alcohol: Not using alcohol.
Drug Use: Not using drugs.
Habits: Sleep habits Sleeping location:Bed. Seeing a dentist. Good exercise habits.
Home Environment: Having home safety plans in case of fire.
Activities: Activities.
Marital: No remarkable marital history.

ALLERGIES
• No Known Allergies

FAMILY HISTORY
Cancer Great Grandmother
Heart disease Great Grandmother and Grandfather
Hypertension Great Grandmother and Grandmother
Depression Mother with depression, Father-schizophrenia, bipolar

PHYSICAL FINDINGS
• Vitals taken 11/23/2011 02:15 pm
Meds and allergies checked and updated-MNG
Used small adult cuff.

BP-Sitting R	112/68 mmHg	90 - 120/50 - 77
BP Cuff Size	Regular	
Pulse Rate-Sitting	98 bpm	55 - 105
Respiration Rate	18 per min	15 - 31

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 11/23/2011 14:15
Provider: SKIFFINGTON MD., EUGENE W.
Encounter: RETURN PATIENT VISIT

Temp-Oral	97.8 F	96 - 101
Height	53.5 in	48 - 57
Weight	104 lbs	42 - 89
Body Mass Index	25.5 kg/m2	
Body Surface Area	1.30 m2	
Oxygen Saturation	97 %	93 - 100

Eyes:

General/bilateral:

Visual Assessment: • Vision assessed.

General/bilateral:

Visual Assessment:	Value	Normal Range
Distance binocular acuity w/o Rx: 20/	30.	18 - 22

Extraocular Movements: ° An ophthalmological sensorimotor exam was normal.

External: • Hyperemia of the conjunctiva.

Right Eye:

Visual Assessment:	Value	Normal Range
Distance right acuity without Rx: 20/	70	18 - 22

Left Eye:

Visual Assessment:	Value	Normal Range
Distance left acuity without Rx: 20/	30	18 - 22

Lymph Nodes:

° Normal.

•

ASSESSMENT

• Conjunctivitis

PLAN

• **OTHER**
Gentamicin Sulfate 0.3 % SOLN, , 7 days, 0 refills, 2 drops OD qid until clear

• Warm compresses

EUGENE W. SKIFFINGTON MD.
Electronically signed by: EUGENE SKIFFINGTON Date: 11/23/2011 14:45

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 10/19/2011 16:15
Provider: CEPEDA, KARLA B. M.D.
Encounter: NEW PATIENT VISIT

Gait And Stance: Gait and stance were normal.

Skin:

The skin was normal. No skin lesions.

Growth And Development:

Normal 6-11 year milestones, shows appropriate behavior at home, shows appropriate behavior at school, shows appropriate behavior when playing with friends, can read and do math at grade level, shows pride in achievements, can talk about what goes on in school, and completes school work.

TESTS

Urinalysis Was Performed:

Urinalysis Results:	Value
Urine pH	5
Urine specific gravity	1.025
Urine bilirubin	1 +
Urine urobilinogen	1 Ehrlich U/ml
Urine leukocyte esterase	75

Normal urine protein, negative for glucose, negative for ketones, negative for hemoglobin, and negative for nitrate.

Laboratory Studies:

Audiometry:

Audiogram (Screening) See scanned results.

J. Riddle.

ASSESSMENT

- Normal routine history and physical well-child (6 - 12)

THERAPY

- Review of immunization history.
- No need for prophylactic fluoride administration.

COUNSELING/EDUCATION

- Anticipatory guidance: meet with teachers; get involved with school
- Anticipatory guidance: limit computer andvideo time
- Anticipatory guidance: play with child
- Discussed safety practices: neighborhood safety
- Discussed use of restraints: use belt positioning booster seat in back seat
- Discussed use of smoke detectors
- Discussed precautions against drowning

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 10/19/2011 16:15
Provider: CEPEDA, KARLA B. M.D.
Encounter: NEW PATIENT VISIT

- Discussed stranger safety
- Discussed street crossing: teach pedestrian safety
- Discussed bicycle safety
- Discussed sports safety -plays soccer
- Discussed concerns about exercise: promote physical activity
- Discussed concerns about dental hygiene: schedule dental appointment
- Discussed concerns about bedtime
- Discussed household chores

PLAN

- **OTHER**

  Request for Records

  Washington Family doctors immunization records

  Referral

  ophtho and ENT hearing test

VACCINATIONS

- DTaP Dose #1 Status: Reported Date: 02/20/2008
- DTaP Dose #2 Status: Reported Date: 01/03/2006
- DTaP Dose #3 Status: Reported Date: 09/21/2004
- DTaP Dose #4 Status: Reported Date: 04/16/2004
- DTaP Dose #5 Status: Reported Date: 01/09/2004
- IPV Dose #1 Status: Reported Date: 02/20/2008
- IPV Dose #2 Status: Reported Date: 09/21/2004
- IPV Dose #3 Status: Reported Date: 04/16/2004
- IPV Dose #4 Status: Reported Date: 01/09/2004
- MMR Dose #1 Status: Reported Date: 02/20/2008
- MMR Dose #2 Status: Reported Date: 01/03/2006
- Varicella Dose #1 Status: Reported Date: 02/20/2008
- Varicella Dose #2 Status: Reported Date: 01/03/2005
- PCV (Prevnar) Dose #1 Status: Reported Date: 01/03/2006
- PCV (Prevnar) Dose #2 Status: Reported Date: 09/21/2004
- PCV (Prevnar) Dose #3 Status: Reported Date: 04/16/2004
- PCV (Prevnar) Dose #4 Status: Reported Date: 01/09/2004
- Hep B Dose #1 Status: Reported Date: 09/21/2004
- Hep B Dose #2 Status: Reported Date: 04/16/2004
- Hep B Dose #3 Status: Reported Date: 01/09/2004
- Influenza A H1N1 Dose #1 Status: Reported Date: 11/30/2006
- Influenza A H1N1 Dose #2 Status: Reported Date: 10/12/2005
- HIb (PRP-OMP PedvaxHIB) Dose #1 Status: Reported Date: 01/03/2006
- HIb (PRP-OMP PedvaxHIB) Dose #2 Status: Reported Date: 09/21/2004
- HIb (PRP-OMP PedvaxHIB) Dose #3 Status: Reported Date: 04/16/2004
- HIb (PRP-OMP PedvaxHIB) Dose #4 Status: Reported Date: 01/09/2004

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 10/19/2011 16:15
Provider: CEPEDA, KARLA B. M.D.
Encounter: NEW PATIENT VISIT

HEALTH REMINDERS

- WELL VISIT satisfied 10/19/2011.

KARLA B. CEPEDA M.D.
Electronically signed by: Karla Cepeda Date: 11/18/2011 14:57

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 10/19/2011 16:15
Provider: CEPEDA, KARLA B. M.D.
Encounter: NEW PATIENT VISIT

SUBJECTIVE
Parent responds normally.
Normal parent/child communication: verbal and nonverbal.

CHIEF COMPLAINT
The Chief Complaint is: Pt presents for new pt appt.
Pt needs form filled out for school. Mother did not bring record of immunizations.

REASON FOR VISIT
Visit for: 7-10 year visit.

HISTORY OF PRESENT ILLNESS
ALEXIS ELLIOTT is a 7 year old female.
She reported: No symptoms.
Bowel movement frequency was normal. Softly formed stools.
Urinary symptoms: urination normal. No changes in urinary habits.
No middle-night awakening.

CURRENT MEDICATION
- ProAir HFA 108 (90 Base) MCG/ACT AERS, as directed, 0 days, 0 refills

ALLERGIES
- No Known Allergies

PAST MEDICAL/SURGICAL HISTORY
Reported:
Surgical / Procedural: No prior surgery.

SOCIAL HISTORY
Diet: Nutritious and satisfying diet, diet sufficient in food variety, and sufficient in dairy products.
Behavioral: No tobacco use.
Alcohol: Not using alcohol.
Drug Use: Not using drugs.
Habits: Sleep habits Sleeping location:Bed. Seeing a dentist. Good exercise habits.
Home Environment: Having home safety plans in case of fire.

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 10/19/2011 16:15
Provider: CEPEDA, KARLA B. M.D.
Encounter: NEW PATIENT VISIT

Activities: Activities.
Marital: No remarkable marital history.

FAMILY HISTORY

Cancer Great Grandmother
Heart disease Great Grandmother and Grandfather
Hypertension Great Grandmother and Grandmother
Depression Mother with depression, Father-schizophrenia, bipolar

REVIEW OF SYSTEMS

Systemic: No systemic symptoms.
Neck: No neck symptoms.
Eyes: No eye symptoms.
Otolaryngeal: No otolaryngeal symptoms.
Cardiovascular: No cardiovascular symptoms.
Pulmonary: No pulmonary symptoms.
Gastrointestinal: No gastrointestinal symptoms.
Genitourinary: No genitourinary symptoms.
Musculoskeletal: No musculoskeletal symptoms.
Neurological: No neurological symptoms.
Psychological: No psychological symptoms and good school performance. No interpersonal relationship problems.
Skin: No skin symptoms.

PHYSICAL FINDINGS

- Vitals taken 10/19/2011 04:15 pm
  Allergies and meds reviewed. J. Riddle

BP-Sitting R	122/80 mmHg
BP Cuff Size	Regular
Pulse Rate-Sitting	130 bpm
Respiration Rate	18 per min
Height	53 in
Weight	101 lbs 6.4 oz
Body Mass Index	25.4 kg/m2
Body Surface Area	1.28 m2
Oxygen Saturation	97 %

General Appearance:
Well-appearing, oriented to time, place, and person, well developed, well nourished, well hydrated, and in no acute distress.

Head:
Injuries: No evidence of a head injury.

Patient: [redacted]
DOB: 10/29/2003
SSN: [redacted]

Date: 10/19/2011 16:15
Provider: CEPEDA, KARLA B. M.D.
Encounter: NEW PATIENT VISIT

Appearance: Head normocephalic.

Neck:

Suppleness: The neck demonstrated no decrease in suppleness.
Cervical Mass: No cervical mass was seen.

Eyes:

General/bilateral:

Visual Assessment:	Value	
Distance binocular acuity w/ current Rx: 20/		20

Pupils: PERRLA.
External: The external eye showed no abnormalities.
Retina: A fundoscopic exam was normal.

Right Eye:

Visual Assessment:	Value	
Distance right acuity with current Rx: 20/		40

Left Eye:

Visual Assessment:	Value
Distance left acuity with current Rx: 20/	10

Ears:

General/bilateral:

External Auditory Canal: External auditory meatus normal.
Tympanic Membrane: Tympanic membrane normal.
Hearing: No hearing loss noted.

Nose:

General/bilateral:

Discharge: No nasal discharge seen.
External Deformities: No external nose deformities.

Pharynx:

Oropharynx: The oropharynx was normal.

Lymph Nodes:

Lymph nodes: normal.

Lungs:

The respiratory excursion was not diminished. Lungs clear to auscultation.

Cardiovascular:

Heart Rate And Rhythm: Heart rate and rhythm normal.
Heart Sounds: Heart sounds normal.
Murmurs: No murmurs were heard.

Back:

Back: normal.

Abdomen:

Auscultation: The bowel sounds were normal.
Palpation: No abdominal tenderness and no abdominal mass was palpated.
Hernia: No hernia was discovered.

Neurological:

Speech: The speech was normal.
Cranial Nerves: The cranial nerves were normal.
Motor: A motor exam demonstrated no dysfunction.

To: PA DEP **April 29, 2015**
From: Cynthia Walter, Ph.D.

I am a scientist with over 25 yrs. experience in teaching and research on environmental topics, including impacts of pollution. My remarks are based on analyses of dozens of peer-reviewed papers, and many talks and interviews with industry scientists, academics, federal and state specialists.

I am saddened by the need to appear yet again in front of you, our state agency representatives, you who were sworn to protect us, to beg for the same, simple protections from a dangerous, heavy industry. This should not be happening.

My comments from last year are printed below in the first 13 pages and list problems of open pits, inadequate replacement water, brine disposal on roads, the lack of electronic records, etc. Pages 14-16 list inadequacies in the proposed regulations and they repeat the same problems. The new regulations still do not meet our basic, reasonable requests.

While you, our protectors, are slowly tweaking regulations that fail to protect us, important events have happened:

1. People impacted with bad water and bad air from fracking have died, and they died from unusual illnesses associated with shale field toxins.
2. Thousands of babies were born to mothers living near wells. At least 2 published studies show increased incidence of birth defects for mothers living closer to wells.
3. More homes have lost their water and property values & public water exceeds limits for THM
4. Several air quality measures have gotten worse.
5. Evidence indicates inadequate DEP documentation of this industry. E.g., Publications reveal that DEP inspectors failed to properly record thousands of cases of well-head failures over several years. Instead, researchers had to read hand-written notes to document a 7 % well head failure rate in the first year and 40 % likelihood of well head failure in the next few decades.
6. Overall, in 500 peer-reviewed publications on shale gas operations in the last 10 yrs,
   90% indicate water problems
   80% document air problem
   70% show human health problems.

   Harm to public health is the most difficult effect to prove in general. The evidence is clear that people are being harmed and many more are at high risk of serious harm.

7. New York State protectors decided to protect their citizens, based on the science of the harm and high risks of the whole shale gas system.

In sum, the science of harm from shale gas operations is the same for PA. We should have the same protections. We need a moratorium. The DEP should be providing more solid evidence of water and air impacts, as they respond to citizen calls and inspect operations. The poor record of well head failures is just one example of DEP's failure to protect. Evidence of air and water before, during and after shale gas operations is chronically difficult to obtain and often only spot checks are done, resulting in no conclusions, no letters of determination and no help for citizens. You are the department of environmental protection, not the department of environmental permits. Please live up to your mission.

To: Environmental Quality Board
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From: Cynthia Walter, Ph.D.
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Re:Proposed Environmental Protection Performance Standards at Oil and Gas Well Sites (25 Pa Code, Chapter 78)

I am a scientist with over 25 years experience teaching and conducting research on water quality in Pennsylvania, and most recently published a report that documents problems and progress to restore streams impacted from coal mining. My remarks are based on analysis of dozens of peer-reviewed papers, and dozens of talks and interviews with industry scientists, academics, federal and state specialists. I submit the following Recommendations to the Environmental Quality Board's proposed regulations, published in the *Pennsylvania Bulletin* on Saturday, December 14, 2013 (43 Pa.B. 7377) and General Comments as a partial rationale to the comments.

Specific Recommendations (All underlined statements)

Accompanying justifications/explanations are not underlined.

1. **Water Used for Fracking (i.e. water to be sent into well)**
   A. **Regulations should not permit open containers or "pits": all fluids should be contained only in closed tanks and closed loop systems.**
   B. **The tanks and closed loop systems should be permitted only for a designated, limited time, e.g., during weeks of fracking.**
   C. **This water should not be called "fresh water."**

   The term "fresh water" is confusing to the public and ambiguous for operators. The so called "fresh water" (i.e. water fresh to a well pad) comes from a wide range of sources each with different, often undocumented contaminants.
   For example, this "fresh water' can be any of the following:
   a. Produced water from a prior well fracking that is intended to be recycled into a future well; therefore, this water will have chemicals from the previously fracked shale deposits (e.g., salts, heavy metals, organic compounds and radioncucleotides) as well as chemicals introduced by the prior fracking company (e.g., acids and preservatives) .
   b. Surface or ground water impacted by another industry, e.g., mercury in rivers downstream from coal burning power plants
   c. Surface or ground water where acid deposition has dissolved naturally occurring metals, such as aluminum.

The water prepared to be put into the well is highly variable in chemistry. It can easily contain enough hazardous chemicals to contaminate the site; thus it must be in closed containers.

Note that the requirement for closed containers/closed loop systems will avoid the use of "natural topographic depressions" within the definitions of an allowed "pit" and/or "freshwater impoundment." No regulations should allow fluids related to oil and gas operations to be managed in "natural depressions."

2. **Produced Water (i.e. water returned from fracking well)**
   A. **<u>Regulations should not permit any open containers.</u>**
   B. **<u>Produced water should be in closed tanks and closed loop systems designed for the broad array of chemicals possible in produced water.</u>**
   C. **<u>The tanks and closed loop systems should be permitted only for a designated, limited time, e.g., during weeks of fracking</u>.**

Note that the requirement for closed containers/closed loop systems will avoid the use of "natural topographic depressions" within the definitions of an allowed "pit" and/or "freshwater impoundment." No regulations should allow fluids related to oil and gas operations to be managed in "natural depressions." All facilities used to hold fluids that may contain potential water pollutants should be closed and specifically engineered for the task.

Produced water contains chemicals from the prior shale deposits (e.g., salts, heavy metals, organic compounds and radioncucleotides) as well as chemicals introduced by the fracking company (e.g., acids and preservatives).
Produced water poses a threat to the water, soil and air.

a. **Water threat**: Concentrations of the chemicals listed above are up to 1000 times the allowed limits in surface or drinking water supplies. Numerous cases of harm to well water, municipal water, and stream life have been recorded in PA and in every formation in the US where deep shale operations have occurred.
b. **Soil threat:** The heavy metals and radionucleotides will permanently contaminate any soil where produced water is spilled. The salts might be washed out, but this simply transfers the problem to water supplies.
c. **Air threat:** Produced water often contains organic compounds released as volatiles such as the carcinogen, benzene, that travel in plums off site. These toxic clouds are hard to measure, but scientists have begun to document their presence downwind from operations, resulting in a prediction of increased cancer risk to residents living near shale gas operations.

The many threats to water, soil and air will not be eliminated with containers and closed loop systems, but this will reduce the most obvious problems. The US Department of the Interior, advises of pits: "Use of enclosed tanks and closed loop or semi-closed loop systems is environmentally preferable to the use of open pits and is to be encouraged by the BLM. Open production pits are to be strongly discouraged. Closed tanks and systems minimize waste, entry by wildlife, fugitive emissions that affect air quality, and reduce the risk of soil and groundwater contamination. In addition, the use of tanks instead of pits expedites the ability to complete interim reclamation. Costs may be reduced with the use of tanks, particularly when the pit requires solidification or netting." Waste pits are banned in New Mexico. According to news articles: Antero in Colorado does not utilize pits, but a closed loop system. Chief and Rex Energy have moved to all closed loop systems. Andarko Petroleum uses close loop systems in

Pennsylvania. The EPA Star program recommends a closed loop system. But Pennsylvania's *new proposed* regulations allow the continuance of frack pits, inviting further pollution and contamination of waters.

3. **Fumes, Mists and Liquids Discharged from Storage Tanks**
   A. **There should be no legally allowed leakage or release of vapors, mists or fluids.**
   B. **Containers that might accumulate vapors, such as condensate tanks or produced water tanks, must have vapor capture mechanisms that prevent the escape of any fumes, especially known toxins such as benzene.**
   C. **Air quality monitors that operate continuously must be installed to verify and report to the DEP that harmful gases are not escaping from the site.**
   D. **Limits for chemical emissions from tanks must take into account**
      (1) **the density of tanks in an area as aggregate air pollution sources**
      (2) **their proximity to buildings with sensitive populations (e.g., schools, hospitals)**

Discharges of vapors and mists during tank checks and leaks during storm water flow are common sources of pollutants. These are occasionally detected by citizens or the DEP, and receive little penalty. Such chronic, small releases add up for the people and animals near the well or industry facility.

The proposed regulations will not prevent flooding, spills, and leak violations that are commonly occurring, but they will motivate operators to plan ahead with a greater margin of safety for liquid and vapor releases. For example, allowing open pits and tanks cordoned off within some general freeboard space, allows a company to receive a lower penalty for a discharge of chemicals if stormwater exceeds the freeboard. Even now, violations due to overflow of the required freeboard occur on a regular basis, companies repeatedly are charged with the same violations, and fines are limited or non-existent.

4. **Seasonal High Water Table**
   The definition of "seasonal high groundwater table" should be retained in the proposed regulations, because the term continues to play a key role in regulating oil and gas activities. (Section 78.1)
   Proposed section 78.1 deletes the definition of "seasonal high groundwater table" even though that term is still used throughout the regulations, including in sections 78.56(a)(11), 78.59b(e). This definition should be maintained to ensure clarity and consistent enforcement.

5. **Fluid Storage Set Back**
   The prohibition on construction of fluid storage areas within 100 feet of certain water bodies should be extended to all water bodies. (Section 78.59c)

   The current draft regulations prohibit well operators from building "centralized impoundments" for wastewaters within 100 feet of any "solid blue line stream" identified by the United States Geological Survey. Solid blue line streams flow consistently year round. This 100 foot buffer is important, but it should be extended to other streams that do not flow continuously. Although we recognize that Act 13 unwisely referred to "solid blue line streams," intermittent and ephemeral streams need to be protected as well. Some of our most vulnerable waters are intermittent portions of high quality streams. Those waters would not be adequately protected by these regulations. Furthermore, the DEP has an obligation to protect intermittent streams under the Clean Streams Law. Rather than attempt to make that decision on a case by case analysis, the DEP should extend this buffer to all Pennsylvania streams.

6. **Investigation of Water Pollution**
   The DEP's duty to investigate water pollution should extend to all oil and gas activities. (Section 78.51(c)).

   The Chapter 78 regulations require the DEP to investigate instances of water pollution that occur near oil and gas wells. As part of its investigation, the DEP may determine that water pollution was caused by the "well site construction, drilling, alteration or operation activities." This set of activities is much more limited than the list of activities defined as "oil and gas activities" in Act 13. To ensure maximum protection of water resources, the DEP's investigation should extend to all oil and gas activities.

7. **Pre-drill Water Testing:**
   a. **All pre-drill water quality testing should be conducted by a certified third-party professional operator, and made available to the landowner .**
   b. **Testing should occur a minimum of 3 times for of water quantity and quality during low, high and average hydrological conditions**
   c. **a consistent list of parameters including at least the following measures:**
      Analyte (Inorganic) Analyte (Trace Metal) Analyte (Organic)
      Alkalinity
      Barium
      Chloride Calcium
      Conductivity Iron
      Hardness Magnesium Analyte
      Hydrocarbons (benzene, ethane, methane)
      Microbiology (Total Coliform/E.coli)
      Oil and Grease Manganese
      pH
      Potassium
      Radionucleotides (alpha and beta)
      Residue – Filterable and Non Filterable
      Sulfate Sodium
      Strontium
      Total Dissolved Solids
      Total Suspended Solids

   The list of items for the test are from the document. "PA-DEP Recommended Basic Oil & Gas Pre-Drill Parameters" (elibrary.dep.state.pa.us/dsweb/Get/Document-91717/8000-FS-DEP4300.pdf).

   Note that DEP water resource specialists such as Swistock and advisors from local county and the USDA consistently recommend 3 water tests to represent high, low and average conditions because in PA, the water table and chemistry can change greatly. Also, 3 water tests are needed to stand up in court. The short time of presumed liability makes it easy for a company to avoid responsibility for damage to a water supply because forces that impact water take time to emerge. In such cases, a court case is likely to require at least 3 sample times to prove good water quality existed prior to operations. Families have lost cases in court because they did not have 3 tests; the drilling company paid for only one test. The necessary battery of tests is too expensive for the average homeowner, but 3 water tests per home is a small cost for a multimillion dollar well operation.

8. **Water replacement**

Contaminated drinking water should be restored to meet the Safe Drinking Water Act standards. If the quality of water was superior to these standards prior to drilling, the operator must restore the water to that higher standard.

Water quality is closely tied to property value and a homeowner with better than average water should have a right to maintain that quality of the property. Also, water quality standards are always being revised; a property with better quality water will more likely meet the new standards. This advantage should not be lost through the fault of the oil or gas facility operator.

9. **Presumption of liability**

Presumption should apply to all oil and gas activities, including site construction.

78.1 The proposed amendments states, "That the presumption of liability established in 58 Pa.C.S. § 3218(c) (relating to protection of water supplies) does not apply to pollution resulting from well site construction activities." This revision gives the oil and gas industry special treatment. Also, far too many actions can be hidden under the phrase of "well site construction activities."

Operations on and near a well pad occur in a mix of actions and timing before during and after well sites are built before during and after drilling and fracking. Furthermore, sites are often modified during and after fracking. No one can separate the effects of "construction activities" from other effects. Also, separating out construction allows one company to attempt to blame another for harm associated with a well operation. This delays and may make it impossible for a harmed citizen to seek redress.

10. **Disposal, Brine and Drill Cuttings:**

There should be no processing of drill cuttings on site nor should cuttings should be stored in pits.

Disposal of brine, drill cuttings, and any residual waste should not be allowed for wells drilled on property not previously designated as a waste site.

No burial of waste should occur on private or public forests, farms, parks, airport buffer, school property, etc. .

Any burial of materials should occur only in sites designated as waste sites and, when burial is thus validated, it should meet the standards of the US Resource Recovery and Conservation Act.

The standards state that residual waste including contaminated drill cuttings may be disposed of on site. This is unacceptable for this or any industry. The storage of contaminated (to any degree) including radioactive drill cutting should be prohibited

Presently, the fracking industry is exempt from the regulation of hazardous substances that other industries must abide by. Those standards should be applied to all aspects of the storage, transport, and use of hazardous materials contained in pits, centralized impoundments, and tanks.

Because Marcellus shale is more radioactive than other shale plays, the drill cuttings can be more radioactive, as evidence by alarms activated at waste disposal sites and the high measurement of radioactivity in a study downstream from the Josephine Treatment Plant in Indiana County which treats wastewater from oil and gas drilling. Radium levels of sediment samples collected in Blacklick Creek, downstream from the plant, were 200 times greater than background samples. Researcher Vengosh noted that levels exceed thresholds for radioactive waste disposal and pose "potential environmental risks of radium bioaccumulation in localized areas of shale gas wastewater disposal." There is no mention that evidence of positive radioactivity or chemical toxicity tests precludes the storage of drill cuttings in a pit or on-site burial.

11. Brine:

No brine from hydraulically fracked wells should be used for application on the well pad, industry access roads, private roads or public roads due not only to salinity loads, but to the possible presence of toxic chemicals and radioactive particles that may be contained in flowback water.

Comments in other sections in this paper emphasize the many toxins present in produced water. Furthermore, each truckload of brine is unique in chemistry depending on the formation and the time of flow from the well. It is impossible for an operator to test and certify the safety of each truckload of brine. Once a load of brine is dispersed, its chemicals will travel through surface flow and infiltration in unpredictable destinations, with unknown consequences. Furthermore, operators have no way to tally the combined effects of more than one brine application in an area. Permission to disperse brine will result in harm to leased property and neighbors due to read chemical presence and the perceived risk of chemicals. Just the permission to use brine will lower options for future use of the land because the presence or absence of a brine application will be hard to verify.

12. Land Application:

No wastewater or drill cuttings should be applied to land areas.

The comments for #11 above apply here as well.

13. Condensate Tanks

All gas facilities including tanks, pits, wells, and compressor stations should have monitors designed and operated by a third party, functioning 24 hours a day, and recording findings that are directly available to the DEP and public.

The gas industry should not be responsible for conducting this monitoring but should be financially responsible for payment of the implementation and conduction of that process. **78.56 (17):**

14. Abandoned Wells:

Those wells must be identified and sealed prior to any gas wells being drilled. Drillers are financially responsible for protecting the waters of Pennsylvania via the identification and plugging process

There are thousands of abandoned wells in PA, increasing the possibility of the migration of methane and other contaminants from fracked wells will move up to abandoned well bores to ground water.

15. **Radiation Monitoring and Labeling- on site and transport**

All liquid and solid waste must be monitored for all relevant forms of radiation and readings must appear clearly on current labels in at least the following conditions:

1). All temporary and permanent impoundments, storage tanks, pits, that collect discharges from wells must be tested at least quarterly.

2) All liquid and solid materials transported to permanent sites such as landfills and injection wells, must be tested and clearly labeled, regardless of whether the destination state requires such labeling.

See below Recommendation # 18 for comments

16. **Management of Radioactive Waste on site**

Drill cuttings that are radioactive should not be disposed of, spread on, nor incorporated into the soil 78.61(b) nor in pits §78.62, 78.63.

See below Recommendation # 18 for comments

17. Management of Radioactive Waste Materials to Disposal Sites

DEP should set standards for radiation monitor alarm set points. Trucks carrying above a certain limit must go to sites designated for radioactive waste.

Trucks below a certain radiation limit and volume might be allowed at a landfill site if the landfill meets at least the following features:

1.) **the intensity and volume of radioactive substances in the landfill has not already reached a pre-determined limit set by the DEP, and verified by a third independent party.**
2.) **The amounts of radioactivity and volumes are publically disclosed on a quarterly basis.**
3.) **Residents within a 5 mile radius of the landfill are informed annually of the radioactivity status**
4.) **The landfill monitors radiation on landfill perimeters and in storm run-off and streams nearby on at least a quarterly basis.**
5.) **The landfill leachate does not move the radioactivity to sites other than those designed for radioactivity. For example, the landfill cannot send radioactive lechate to municipall waste water treatment plants.**

Radiation should be specifically addressed in the new regulations. Other regulations are not sufficient to guide the current oil and shale gas industry because of the uncertain status of various regulations and the use of varied terms. For example, the Solid Waste Management Act (35 P.S. §§6018.101-1003), referred to §78.58(d) has limited provisions for radiation.

Also, the *Guidance on Radioactivity Monitoring at Solid Waste Processing and Disposal Facilities* (Document 250-3100-001) was offered only as a best management practice in the absence of regulation. This *Guidance has many deficiencies:*

a. It carries no regulatory authority.
b. It is dated written in 2004,
c. It handles only small quantities of TENORM,
d. It did not anticipate the nature and volume of fracking waste disposed in landfills.

"Waste Disposal" (para 2) is among the topics included in this Act, yet omits two items. The Act omits 1) the handling, monitoring and storage of radioactive waste and 2) waste disposal in landfills an industry-accepted method of disposal of the waste of the hydraulic fracking process, fracking fluid and drill cuttings.

Current language of the Act calls this waste "contaminated" (e.g. §78.62), yet classifies it as "residual waste." Fracking fluid and drill cuttings in Pennsylvania are known to contain at least Radium-226, a radioactive material. Therefore provisions should be made for measuring radiation and handling waste appropriately. Radium-226 has a half-life of 1601 years and will forever remain to impact the health of residents and the environment.

The ACT fails to mention Radium-226, TENORM or the radioactive nature of this waste. In fact, "radioactive" is found once in the document in §78.123 regarding logs maintained on the well.

18. The permit applicant, not the Department of Environmental Protection (DEP), should be responsible for determining whether proposed oil and gas operations would affect threatened or endangered species, through the use of an independent, professional analyst with a report provided to the DEP and the public. (Section 78.15(d))

Protecting the habitat and physical safety of vulnerable species is a critical part of ensuring biodiversity and the quality of our environment. The federal Endangered Species Act was designed to achieve these goals by making it unlawful for any person to harass or take a listed species, including adversely affecting the habitat of a listed species in a manner that effects a take. Similarly, state law currently imposes the obligation on operators to ensure that their activities will not adversely affect listed species or their habitat.

The proposed regulations change that obligation by only requiring gas operators to mitigate the impact of their operations on threatened or endangered species if the DEP determines that the well site location will adversely impact species or "critical habitat."

Because an operator proposing an oil or gas project stands to gain financially from the project, and is in the best position to understand the scope and potential impact of its proposal, the operator (and not the DEP) should have the burden of paying for an independent party to determine whether its project would affect listed species and their habitat.

The analysis of the habitat and the species at risk can then be reviewed by the public.

19. Response to Comments

The DEP should respond to comments received about a permit that may affect an important public resource. (Section 78.15(d))

The proposed regulations allow for a public resource agency to receive notice of, and submit comments about, a proposed well permit that would affect its resources. The regulations, however, do not require the DEP to respond to those comments. To ensure that comments are adequately considered and that public resources are fully protected, the regulations should require the DEP to respond to comments submitted by public resource agencies.

20. Citizen and Environment Protection

The DEP should not compromise its obligation to protect citizens and the environment by balancing the citizens' constitutionally guaranteed right against private interests in oil and gas. (Section 78.15(g))

The DEP is required by the Pennsylvania Constitution to protect the public's right to a clean environment. The proposed regulations provide that even though the DEP determines that a proposed well will have a probable adverse impact on a public resource, the DEP still cannot impose conditions that will prevent or mitigate that harm without first considering the impact of the condition on the individual mineral right owner's ability to "optimally" develop his or her oil and gas rights. This regulation inappropriately places the DEP, whose mission is supposed to be to protect and conserve Pennsylvania's environment, in the position of balancing protection of important public resources against individual property rights. Furthermore, it inappropriately, and potentially illegally, elevates the "optimal" development of oil and gas over the protection of important public resources against likely adverse impacts. These draft regulations do not give proper weight to the DEP's constitutional obligation to protect the environment. So long as the DEP's actions do not affect a taking of private property, the DEP should be obligated to take whatever actions are necessary to condition permits in a manner that protects important public resources.

General Comments in support of recommendations to revise the proposed ammendments

The proposed amendments do not provide appropriate protection to the environment or the health and welfare of citizens of Pennsylvania.

In Pennsylvania, we have new shale gas wells within 2 miles of at least 190 day care facilities, 223 schools, and 5 hospitals. Many new shale wells are immediately above or adjacent to well water and municipal water supplies for over two million citizens and many wells are on or adjacent to property with critical public food supplies such as dairy herds. These herds put us fourth in the nation in milk production and top in the number of farms. The DEP has much to protect including a tourism industry of $33 billion and agribusiness of $32 billion. Hunting licenses alone collect almost $1 billion. All this depends on people trusting that our air, land and water are not contaminated or at risk for harm in the future.

The new technologies of shale oil and gas development have created health and environmental impacts scientists have just begun to document. A pattern of harm from normal operations and accidents is emerging. Over 161 letters have been sent out by the DEP to residents indicating water sources were contaminated by fracking. In just 2 years, from 2008 to 2010, the DEP recorded thousands of violations of environmental regulations and 241 were at well sites within 2 miles of day care centers and 40 within 2 miles of schools. Many peer reviewed scientific publications and records from the EPA, PA DEP, and agencies from other states document substantial contamination from deep shale oil and gas development in just the last decade, often originating from surface operations. These wells and their waste will be part of PA decades after the oil & gas are gone. We must limit the damage with clearer, more pro-active regulations.

Peer-reviewed scientific reports of impacts from shale gas development under normal operations:

McKenzie 2010 Univ. Colorado - persons living within ½ mile of fracking operations have an increased risk of disease-- both cancers and non-cancers-- due to exposure to airborn toxic chemicals from normal operations.

Adgate 2010 - Colorado School Public Health - chronic health risks near drilled areas were greatest (in order of prevalence) for neurological disease, hematological disease, respiratory effects, and developmental effects.

Mead 2012 – PA Academy Of Natural Sciences."As the density of well pads increased, the number of types of stream insects decreased,"

Hill 2012 - Cornell University – A 25 % increased prevalence of low birth weight and lower apgar scores occurred for babies of mothers who experienced their pregnancy near frack operations.

Currie 2014 - Princeton - Pennsylvania infants born within 2.5 kilometers of frack sites have higher incidence of low birth weight. The chances of a low apgar score doubled. (in Review)

Warner 2013 - Duke University study found methane 6 times higher and ethane 23 times higher if a home was within a kilometer of a gas well, probably through natural pathways underground.

Schug 2013 - University of Texas - Elevated concentrations of arsenic and selenium were in water closest to gas extraction sites.

Nagel 2013 - water samples from sites in a drilling dense region of Colorado exhibited more estrogenic, anti- estrogenic, or anti-androgenic activity than reference sites.

States – 2013 – Pittsburgh Water Authority – Industrial treatment facilities accepting oil and gas waste legally release bromides into source waters, raising drinking water contaminants above allowed limits.

Papers involving a mix of normal operations, poor management and/or accidents:

Osborn 2010 - Duke University - water wells within 1 mile of fracked gas wells had 17 times the methane as reference sites.

Bamberger 2012 – Cornell - farm animals with neurological, reproductive, and acute gastrointestinal problems after being exposed to fracking chemicals

Vengosh 2013 - Duke University - brine from Marcellus shale containing bromide and radioactive radium was incompletely treated and contaminated a PA river upstream from drinking water intakes.

Comments regarding revisions in Oil and Gas Operation Regulations – April 29, 2015

All regulations must apply to both unconventional and conventional drilling. Conventional wells also use water and chemicals, create waste, and disturb land. Conventional operators, like unconventional operators, cause spills, accidents, and contamination. Due to the inherent risks of all oil and gas development, DEP should require all operators of all wells to follow the same rules.

A. **Frack pits & impoundments (Sections 78.56, 78.57, 78.58, and 78.59)**

1. **Frack pits should be prohibited.** Frack pits leak and emit hazardous air pollutants, polluting both air and water. DEP should amend the final regulations to: prohibit operators from utilizing any open-air pits and tanks regardless of size or location for storage and treatment of drilling and fracking wastes, including wastewater, drill cuttings, and dangerous substances (like gels and cement) that return to the surface after fracking. The new revisions prohibit the use of production pits at shale gas well sites, an important change that should be supported, but the use of huge open impoundments to service multiple wells will still be allowed. This latter situation is not acceptable.
2. **Centralized impoundments should be prohibited.**
3. **All waste impoundments should be required to be properly closed immediately upon the effective date of the regulations.** Allowing operators 3 years to properly close their existing impoundments, allows toxic pollution to continue, threatening air and water quality.
4. **Tanks used for the storage of waste must be completely enclosed.** The revisions give operators the option of using tanks "without lids" to store waste on well sites; this allows spills to occur and air emissions to escape.
5. **The onsite processing of shale drill cuttings should be prohibited,** which often contain hazardous substances and radioactive materials and require thorough analysis and special handling.
6. **Define "freshwater" that is used in oil & gas operations**. Water leftover from fracking and contaminated fluids being recycled for fracking (such as from mining or sewage) is often mixed with clean water for additional operations. The lack of a clear definition allows operators to avoid regulations on the use and disposal of polluted substance.
7. **End the use of all open-air production pits for the storage of waste and require the immediate conversion to closed tanks**. Conventional well operators should not be permitted to store their waste in pits and to bury waste at well sites .
8. **Conventional well operators should develop water management plans that specify the source and volume of the water used in site construction, drilling, hydraulic fracturing, and site restoration.** This is only required for unconventional but not conventional operators. All gas development requires large volumes of water and withdrawals can harm streams, rivers, and aquifers.

B. **Disposal of brine, drill cuttings, and residual waste (Sections 78.60, 78.61, 78.62, and 78.63, and 78.70)**

1. **Prohibit the burial or land application of drill cuttings**, which can contain polluting and radioactive substances.
2. **Prohibit the onsite burial of waste pits**. Buried pits can leak and pollute groundwater over time, yet burial allows operators to walk away from any responsibility after completing operations.
3. **Prohibit the land application of tophole water, pit water, fill, or dredged material.** These substances can contain chemicals and sediments bound with pollutants that pose risks to water, air and soil.
4. **Prohibit the road spreading of brine/gas wastewater from conventional wells**. The standards would continue to prohibit the use of wastewater (brine) from unconventional wells as a de-icer

and dust suppressant, but continue to allow waste from conventional wells to be used for these purposes. Brine contains chemicals, hydrocarbons, and concentrated salts regardless of the type of well it from which it was taken. Limits have been established on contaminant levels in the brine, but there is not a requirement for testing for all contaminants that could be present, requires minimal testing and monitoring, and has not provided scientific evidence that road-spreading is safe for water, vegetation, and wildlife—especially over large areas for prolonged periods of time.

C. **Public resources should be more clearly defined and meaningful protection provided.** (Section 78.15, 78.57, 78a.15, 78.57a)

1. **Set back distances from schools should be at least 1.5 miles.** DEP has added schools to the list of public resources that require additional consideration when permitting oil and gas wells and has extended the setbacks of waste storage from school buildings, parks, and playgrounds. Those setbacks are inadequate. Recent evacuation zones have been 1.5 miles, the minimum distance fracking should occur from any school.
2. **This setback should also be applied to locations where other vulnerable populations reside, including nursing homes, hospitals, day care centers.**
3. **All the setbacks in the public resource section are too small** to provide the needed protection and must be expanded to include more sensitive resources, such as private water wells and all our streams and rivers. Current science supports greater protections; see the compendium from Physicians, Scientists and Engineers for Healthy Energy: http://www.psehealthyenergy.org/site/show_list/id/15

D. **Any affected drinking water supplies must be restored either to Safe Drinking Water Act (SDWA) standards or, if pre-existing water quality was higher than SDWA standards, to the better pre-existing condition.**

1. All drillers to use a consistent list of parameters for pre-drill water testing, which DEP must establish before the proposed regulatory changes are adopted.
2. All drillers make pre-drill data available to the public, while protecting individual homeowners' privacy, through an online platform, which DEP must establish before the proposed regulatory changes are adopted.

E. **Orphaned and abandoned gas wells should be identified and plugged prior to new well site construction.** (Section 78.52a)

1. **Existing wells should be identified through onsite inspection before site and well construction and drilling so that the location of a new well won't trigger a pollution incident or pose dangerous conditions.** The state doesn't commit funding to address the large number of old wells, so drillers should be responsible for preventing water and air pollution and for avoiding catastrophes.
2. **Identified old wells should be mapped on a publicly available web platform.**
3. **A greater area than 1000' should to be surveyed and inspected for the presence of orphaned or abandoned wells.** Interaction between a newly drilled well and an old well can occur at much greater distances than 1000' if there is a subsurface connection; scientific research should be used to set safe setbacks. The Federal Bureau of Land Management's new rules for fracking on public and tribal lands released in March require a survey of a half-mile; Pennsylvania deserves equal protection.

F. **Provisions must be updated to result in meaningful noise reduction.** This is a human health issue because the sustained noise impairs sleep, increases blood pressure, etc. The provisions will not result in meaningful noise reduction or control at well sites. The noise requirement is vaguely worded and fails to set an objective standard for evaluating problems, making it difficult, if not impossible, to assess compliance.

H. Oil and gas operators should be required **to electronically file permit applications and all required reports and those documents should be made available to the public on DEP's website.** This should be posted the same day they are deemed complete by DEP. Easy and timely access to information by the public is necessary to ensure agency transparency and operator accountability.

Glenn Weaver

823 Congress Hill Rd
Franklin, Pa. 16323

My name is Glenn Weaver , I am a 4th generation shallow oil producer in Venango County Pennsylvania.
My son who is in partners with me is a 5th generation.
The regulations for Act 13 will put the little oil producer out of business. For 20 some years the regulations for Act 223 have governed the conventional oil and gas industry. There is no need for this ridiculous change in regulations.
If we did not live by the regulations we were fined if need be. Our production water from shallow oil and gas wells has the same density of salt as the 2 oceans that surround us.
The water from 4000ft and below is severely salty and needs to be disposed of properly.
For 150 years our shallow production water has been dispersed on the ground with no serious problems. I shall never forget in 1988 after Act 223 had been passed several of us PIPP members were setting in Gov. Casey's office with people from the original DER Arthur P Davis was the deputy secretary at that time and was in our meeting They were beginning to discuss the production water problem and one of our members read a document published by the DER that the springs in North western Pennsylvania were the greatest in the state and he asked Arthur Davis how this could be? When for years our production water was dispersed on the ground. Mr. Davis replied we are trying to figure that out.

At this time with oil at approximately $50 per bbl. For every bbl of oil produced we are spending over half of it for water processing and trucking. There has got to be other systems.

Two years ago we applied for a stream permit to discharge water into a none high quality stream by treating it. We have been stalled all this time for the permit and

the DEP has added approximately $400 per month for radiation testing making the grand total of $1200 a month just for testing fees.
I now question if we will ever see the permit.

IN my life time of being in the oil business we have seen ups and downs in oil prices but we could always jump to excavating to make a living but the guy we call president has our economy in such a mess that that is no longer possible.

If we lose the oil and gas business Pennsylvania economy will be in a mess. Those that are here tonight wanting to stop drilling and fracking should have walked here instead of driving a car or at least rode a horse and wore wooden shoes because everything they wear has some oil in the process of making it.

SAVE OUR INDUSTRY PUT THE CONVENTIONAL OPERATORS UNDER THE REGULATIONS WE SUCCESSFULLY LIVED AND OPERATED UNDER FOR 20 SOME YEARS.

PO Box 4023
184 South Main Street
Washington, PA 15301

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organizing educating empowering

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April 29, 2015

Comments on Proposed Changes to Chapter 78 Regulations

Thank you for the opportunity to provide comments on the Department's proposed changes to Chapter 78 regulations. My name is Caitlin McCoy and I am an environmental attorney and the Legal Director of the Center for Coalfield Justice, which is located here in Washington. The Center for Coalfield Justice was founded in 1994 by individuals organizing against the destruction caused by longwall coal mining. Over the last 20 years, we have expanded our mission to work on issues related to extractive industries generally in Washington and Greene counties. CCJ has nearly two thousand members and supporters, most of whom live in Washington and Greene counties and live with the daily impacts of fossil fuel extraction.

Today, I will address four main areas of concern:

Limits of Disturbance

- The 200-foot limit of disturbance distance for a publicly owned park, forest, game land or wildlife area, historical or archeological site and National natural landmark is too short to provide adequate protection to those important public resources. Noise and air pollution and the risk of significant impacts can be far reaching. We suggest this distance be amended to at least a mile for such public resources.
- DEP has added schools to the list of public resources that require additional consideration when permitting oil and gas wells and longer setbacks of waste storage from school buildings, parks, and playgrounds. However, the 200-foot limit of disturbance for common areas on a school's property is far too small to offer even limited protection from health risks.
- To improve protection from pollution, noise, and light, and safety from traffic, accidents, and explosions, DEP should require, at minimum, a one-mile setback of oil and gas wells, waste storage facilities, and any other infrastructure from the boundary of any school property.

Public Participation

- Hearings and comment periods should be required for all proposed drilling-related activities, including well pads, impoundments, and pipelines.
- We support the proposal to require oil and gas operators to file permit applications and required reports electronically. DEP should also ensure all electronic filings and reports made by operators are available to the public on DEP's website on the same day they are deemed complete by DEP. Public availability of timely information is

necessary to improve agency transparency and operator accountability, two issues which were revealed to be extremely problematic by the Auditor General's Performance Audit last July.

Pits, Impoundments & Waste Management

- Issues with frack pits have led to contaminated water and resulted in the largest state fines ever against a driller in Pennsylvania, both over $4 million, to Range Resources and XTO for water contamination due to leaking pits.
- DEP should amend the regulations to prohibit operators from using any open-air pits and tanks, regardless of size or location, for storage and treatment of regulated wastes, including wastewater, drill cuttings, and substances that return to the surface after fracking. The new revisions prohibit the use of production pits at shale gas well sites, an important change that should be supported. However, huge impoundments to service multiple wells are still allowed. DEP should standardize the use of aboveground closed loop systems for the storage and treatment of waste.
- We remain concerned that sections 78.56(d) and 78.62(a)(15) allow for residual waste pits to be filled in, burying waste onsite. Under section 78.62, residual waste, including contaminated drill cuttings, must be stored in a lined pit with a bottom at least 20 inches above the seasonal high groundwater table. Those protective requirements are ultimately rendered ineffective after the operator fills in the pit and waste has an opportunity to migrate into the groundwater. The regulations state that the pit should be filled 18 inches over the top of the liner and graded to promote runoff with no depressions that would accumulate or pond water on the surface. This ignores the reality that the soil used to backfill the pit will absorb harmful constituents from the waste and the soil layer on top can shift and erode over time.
- DEP should require all waste impoundments to be properly closed immediately upon the effective date of the regulations. The revisions give operators 3 years to either properly close their existing impoundments or bring them into compliance with the construction requirements in residual waste permits. This is an improvement but still puts nearby residents and the environment at risk.
- DEP should require that tanks used for the storage of waste be completely enclosed. The revisions give operators the option of using tanks "without lids" to store waste on well sites—making it more likely that harmful spills and emissions will occur.

DEP Investigations

- Section 78.51(b) provides procedures for notifying DEP of water pollution or diminution of a water supply to request an investigation, but only covers impacts "as a result of well site construction, well drilling, altering or operating activities...." It is unclear whether "operating activities" includes all of the activities listed under "Oil and Gas Operations" in the definitions section of the regulations which provides a comprehensive list of activities. DEP should clarify this uncertainty by including the full range of activities listed in the definition of "Oil and Gas Operations" as actions that can trigger an investigation.

Testimony
Chapter 78 Public Hearing
Washington, PA
April 28, 2015

Dustin J. Kuhlman, P.E.
470 Arden Road
Pittsburgh, PA 15216

I am a Professional Engineer licensed to practice within the Commonwealth. I have 18 years of professional experience and am employed by Civil & Environmental Consultants, Inc. of Robinson Township where I hold the position of Vice President and manage the company's Natural Gas Industry Consulting Group. I am here tonight speaking as an individual citizen; not on the behalf of my employer.

With that said, I think that it is important that I communicate to you that the Natural Gas Industry is important to me relative to my job. It represents over 1/3 of the annual revenue generated by my company; it has facilitated career growth that would not have otherwise been possible for me and many of my co-workers; it supports over 100 jobs that I am responsible for in CEC's three Pennsylvania locations; and it played a key role in bridging the gap for us when practically all of our other market sectors were suffering in 2008 and 2009.

I have worked with natural gas producers, midstream companies and those involved with processing and treatment since 2008. The services that my company provides are centered on helping these companies conduct their activities in an environmentally safe and responsible manner. We perform environmental investigations and engineering services; we work with the PADEP to obtain permits and assist with compliance. In this capacity, I have had the unique perspective of witnessing and, for a large part, living the evolution of the PADEP's regulatory framework for the natural gas industry since the Marcellus Shale became a viable production option. My experience has helped me draw the conclusion that Pennsylvania's regulation of the Natural Gas industry is comprehensive and very thorough. Furthermore, I have worked closely with the staff at the PADEP throughout my work in this industry and have confidence in their will and their ability to protect the resources of the Commonwealth.

It is my opinion that the regulations proposed in Chapter 78a in this rulemaking go too far. They propose regulation that will not result in appreciable benefit to the environment, yet will have a crippling effect on the industry that is so important to the economic viability of our Commonwealth, this region, my Pennsylvania-based employer, others like it and me. I urge the Department to reconsider this action in favor of a more balanced approach that includes the input of all stakeholders, including the regulated community.

I offer the following specific points:

1. The rulemaking contains standards that are only applicable to the Oil and Gas Industry. The wastewater treatment; noise; storage tank; and waste reporting standards included in the proposed document will unfairly burden the Natural Gas industry in comparison to other industries operating within the Commonwealth.
2. The rulemaking eliminates the text proposed under the December 13, 2013 rulemaking relative to Centralized Impoundments and effectively eliminates impoundments from the list of available facilities that can be utilized to store and recycle flowback and produced water. Speaking from experience, the Department, industry and the consulting community have invested vast amounts of time and resources to develop design and construction standards for centralized impoundments that have been proven to result in the construction of safe and reliable facilities. The most recent standards included robust liner system and subgrade requirements, groundwater protection standards and provisions for ongoing monitoring. It would be a shame to eliminate this as a viable option at this stage in the evolution of the PADEP's regulations. Unintended consequences of this rule could include less water recycling, more truck traffic associated with water transfer and more earth disturbance being necessary to site tank farms. I speak from direct experience when I say that these impoundments can and have been built and operated in a safe and environmentally sound manner with proper design, construction oversight and operational controls.
3. The rulemaking will result in significant compliance costs at a time when the industry is already facing difficulty due to slumping commodity prices. The net effect of this is that it will make Pennsylvania less competitive with respect to its neighbors and other shale basins with little additional environmental benefit.
4. Pennsylvania already has world class environmental standards and regulatory staff. Let's let those work for us in lieu of creating new, overly burdensome regulation that singles out the very industry that helped carry us through the great recession.

Washington

April 29, 2015

John Quigley, Acting Secretary of Environmental Protection
16th Floor, Rachel Carson State Office Building
400 Market Street
Harrisburg, PA 17101

Proposed Regulations for Oil and Gas Surface Activities (Amendments to 25 Pa. Code Chapter 78, Subchapter C) and Rules And Regulations, Title 25—Environmental Protection, Department Of Environmental Protection [25 PA. Code CHS. 78 and 78a] Environmental Protection Performance Standards at Oil and Gas Well Sites

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Information on Environmental Protection and Structural Integrity with Geosynthetic Systems

Introduction

In response to the recent publication of the Draft Final Rulemaking: Environmental Protection Performance Standards at Oil and Gas Well Sites, **GMA offers the following additional comments and information (including attached appendices):**

Geosynthetic Materials Association,(GMA) is an industry trade group of over 80 companies that manufacture, distribute and install geosynthetic materials, including liners systems. The industry employs 12,000 people throughout the United States and has a market size of over a billion dollars per year..

GMA compliments the Pennsylvania Department of Environmental Protection (PA-DEP) and the Pennsylvania Environmental Quality Board (PA-EQB) for the statements and inclination to require geosynthetic lined facilities designed to protect the groundwater from potential contamination in the processes of oil and gas exploration and extraction.

However, GMA would like to point our deficiencies in the approach, language and standards used to attempt to accomplish this.

GMA recommends that the regulations put forth require the use of a composite liner system (geomembrane and geosynthetic clay liner) as this system has been demonstrated (by PA-DEP and the United States Environmental Protection Agency (USEPA)) to be the most effective barrier methodology, regardless of the classification of the materials contained (hazardous, non-hazardous or designated for beneficial re-use, solid, liquid or mixtures). This comment contains additional references to USEPA reports and studies as well as test data generated, using USEPA protocols that support the effectiveness of composite liner systems and their components. Lacking the construction of a composite liner system, as the existing proposed regulations exist currently, the language and complete lack of application of existing standards for inspection of the synthetic liner are likely to result in environmental contamination and do not use current technology and as such, are well out of date.

Statement of proposed requirement(s)

In 25 Pa. Code Chapter 78 (and (a)), the proposed regulations discuss the requirements of synthetic liner systems as follows:

Section § 78.57. Control, storage and disposal of production fluids.

(vi) The pit is impermeable and is lined with a synthetic flexible liner or alternate material that has a coefficient of permeability of no greater than 1 x 10-7 cm/sec. The liner shall be of sufficient strength and thickness to maintain the integrity of the liner. The thickness of a synthetic liner shall be at least 30 mils. Adjoining sections of liners shall be sealed together in accordance with the manufacturer's directions to prevent leakage.

(vii) The physical and chemical characteristics of the liner shall be compatible with the waste and the liner is resistant to physical, chemical and other failure during transportation, handling, installation and use. Liner compatibility shall satisfy EPA Method 9090, Compatibility Test for Wastes and Membrane Liners, or other documented data approved by the Department.

(viii) The pit shall be constructed so that the liner sub base is smooth, uniform and free of debris, rock and other material that may puncture, tear, cut, rip or otherwise cause the liner to fail. The liner sub base and subgrade shall be capable of bearing the weight of the material above the liner without settling in an amount that will affect the integrity of the liner. If the pit bottom or sides consist of rock, shale or other material that may cause the liner to leak, a sub base of at least 6 inches of soil, sand or smooth gravel, or a sufficient amount of an equivalent material shall be installed over the area as the sub base for the liner.

(ix) Prior to placing brine or other fluids in the pit, the operator shall inspect the liner and correct all damage or imperfections that may cause the liner to leak.

Further, as a general statement of intent, PADEP publishes the following statement on their website:

Containment Practices Inadequate containment practices pose a potential threat of pollution to the waters of the commonwealth. The containment provisions included in this proposed regulation were carefully developed based on DEP's inspection and field experience. Act 13 includes new containment systems and practices requirements for unconventional well sites. There are many options for containment that the oil and gas industry uses and is constantly developing improvements for, so DEP must be on the forefront of the curve.

Respondent comments

With all due respect, if it is the goal of the PADEP and the PA-EQB to be "on the forefront of the curve" the language and requirements of the proposed regulations require significant changes. While this may appear to be a very strong statement, the good news is that the PADEP has an excellent track record in the use of composite liners, geosynthetic materials and proper application of their usage and possesses significant expertise in this regard. Further, there is an institution located within the commonwealth that is the preeminent global leader in the use and application of these materials. That is the Geosynthetic Institute located in Folsom, Pennsylvania. The directors of the Institute have commented on the proposed regulations. Their comments are included with this commentary and deserve a serious review and integration into the regulatory process.

GMA would like to ensure that the PADEP and the PA-EQB are aware of all pertinent information related to the effective use of geosynthetic materials for waste containment. The Geosynthetic Institute (Drs. Robert and George Koerner, Folsom, PA) website contains an index of the U.S. EPA documents that are related to the use of geosynthetics. The complete list is attached as an Appendix "A". Further, a link to the webpage is here: http://www.geosynthetic-institute.org/epa.html. Clearly, geosynthetic materials have been well examined and proven to be effective.

GMA would like to state our concurrence with the opinions and information previously supplied to the docket by The Geosynthetic Institute in their letter and commentary dated March 10, 2014 (Appendix "B"). In the interest of brevity, GMA does not re-supply the technical reference materials listed in that document and available on the Geosynthetic Institute website.

However, based on the technical information presented therein, GMA recommends that the Proposed Rule be revised to use current practices for inspection and the verification of the geosynthetic liner system integrity

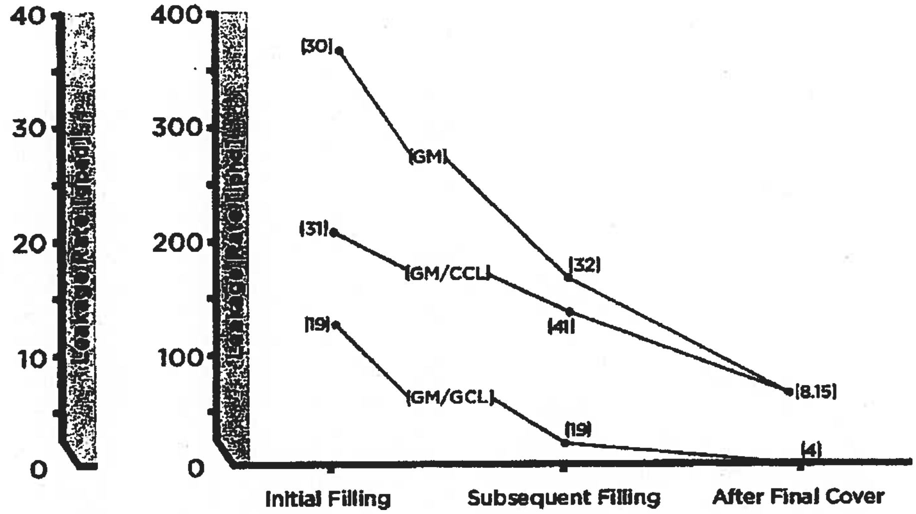
The regulations currently call out a synthetic liner and require the liner be inspected. To wit: "the operator shall inspect the liner and correct all damage or imperfections that may cause the liner to leak". This requirement is very poorly stated and presents several issues. Who is qualified to make such an inspection? What should the inspection entail? What level of damage is allowable?

The responder wishes to bring to the attention of the PA EQB that there are well established protocols for determining the integrity and barrier performance of synthetic liners. Multiple ASTM (American Standard Test Methods) methods exist and are detailed in the appendices C through F. These well established, documented and reliably demonstrated protocols exist to establish the integrity of the synthetic liner and assure protection of the environment. There are also systems in place that can provide continuous monitoring of geosynthetic liner systems. A standard that does not require the usage of these systems and protocols cannot be considered to reflect current engineering and technical practices and certainly does not meet the stated intention of the standard to "on the forefront of the curve".

In another topic, GMA also wishes to point out to the Board the historical performance of system recommends described as a 'composite liner', consisting of two components: An upper component consisting of a minimum 30-mil flexible membrane liner (FML), AND a lower component consisting of either at least a two-foot layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/s, or a geosynthetic clay liner (GCL) containing at least 0.75 lb/ft^2 of sodium bentonite. While a two foot layer of clay may not be technically and economically feasible for these systems, the use of a GCL within a composite system is extremely effective, in fact, historically demonstrated to be the best available technology.

The prescriptive liner system described under US EPA Subtitle D (40 CFR Part 258) is a composite liner with two components: an upper component consisting of a minimum 30-mil flexible membrane liner (FML, also commonly called a geomembrane), and a lower component consisting of at least a two-foot layer of compacted soil with a hydraulic conductivity of no more than 1 x 10-7 cm/sec. This system, utilizing a geomembrane /synthetic liner and a clay component has been extremely successful over the past several decades at containment of liquids (and solids) with significant potential for environmental damage. This has been evaluated on multiple occasions. Appendix "B" lists one document of particular interest titled "Assessment and Recommendations for Improving the Performance of Waste Containment Systems" by R. Bonaparte, D.E. Daniel, and R.M. Koerner, US EPA publication: EPA/600/R-02/099 (Appendix G) One figure illustrating data from this document illustrates the relative performance of various systems, a geomembrane / synthetic liner alone, a composite liner consisting of a geomembrane / synthetic liner with compacted clay and a composite liner consisting of a geomembrane / synthetic liner with geosynthetic clay liner. Leakage rates are plotted over time expressed as the stages of the containment site.

[→] LANDFILL LINER SYSTEM PERFORMANCE



[Ref: 2002 Bonaparte, Daniel and Koerner, U.S. EPA]

Clearly composite liners, particularly those utilizing a GCL have a successful track record in containment applications. Also clear is the fact that a geomembrane/synthetic liner alone is the least effective system.

Conclusion
The benefits and successes of utilizing geosynthetic barriers in containment systems has been well documented by the technical materials supplied by GMA contained and further referenced here. Geosynthetics have been tested and successfully evaluated in great detail over a long period of use in a very wide range of applications by PADEQ and pioneered, investigated and for the last several decades improved by the Geosynthetic Institute.

GMA recommends that the existing technology and protocols for geosynthetic liner integrity testing and verification be used to assure that these systems perform as desired and contain the liquids that they are designed to and capable of containing.

GMA recommends that the Proposed Rule require a 'composite liner' consisting of two components: An upper component consisting of a minimum 30-mil flexible membrane liner (FML), and a lower component consisting of a geosynthetic clay liner.

GMA thanks the Commonwealth for the consideration provided. GMA, the respective member companies and their staffs are more than willing to respond to any additional inquiry on this or other related topics.

Sincerely,

Boyd Ramsey

Chairman: Executive Council
Geosynthetic Materials Association
Industrial Fabrics Association International
1801 County Road B West
Roseville, MN 55113-4061

Chief Engineer
GSE Environmental LLC
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Houston, TX 77073

Appendix "A"

Geosynthetic Institute

U. S. Environmental Protection Agency

U. S. Environmental Protection Agency (EPA)

U. S. Environmental Protection Agency (EPA) Research Publications which involve Geosynthetic Materials (published from July, 1973 to January, 1995)

Available through NTIS:
National Technical Information Service (NTIS)
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Phone: (703) 487-4650
(FTS) 737-4600

The SWR No. is identified through the U. S. EPA Solid Waste Research Publications Department.

Covers
Design and Construction of Covers for Solid Waste Landfills, EPA 600/2-79/165
NTIS No. - PB 80-100381
SWR No. - 567

Evaluation of Municipal Solid Waste Landfill Cover Designs, EPA 600/2-86/110
NTIS No. - PB 88-171327
SWR No. - 927

The Use of Alternative Materials for Daily Cover at Municipal Solid Waste Landfills, EPA 600/R-93/172
NTIS No. - PB 93-227197
SWR No. - 1121

Liners
Use of Liner Materials for Land Disposal Facilities, SW 732
NTIS No. - N/A
SWR No. - 539

Preventing Landfill Leachate Contamination of Water, EPA 670/2-74/088

NTIS No. - PB 238145/AS
SWR No. - 434

Evaluation of Liner Materials Exposed to Leachate--Second Interim Report, EPA 600/2-76/255
NTIS No. - PB 2599336/8BE
SWR No. - 548

Liner Materials Exposed to MSW Leachate--Third Interim Report, EPA 600/2-82/097
NTIS No. - PB 83-147801
SWR No. - 769

Field Verification of Liners from Sanitary Landfills, EPA 600/2-83/046
NTIS No. - PB 83-217810
SWR No. - 771

Compatibility of Flexible Membrane Liners and MSW Leachates, EPA 600/2-91/040
NTIS No. - PB 91-231522
SWR No. - 1018

Proceedings of the Workshop on Geomembrane Seaming: Data Acquisition and Control, EPA 600/R-93/112
NTIS No. - PB 94-114667
SWR No. - 1117

Pollutant Generation
Estimating Leachate Production from Closed Hazardous Waste Landfills, EPA 600/2-86/057
NTIS No. - PB 96-207503
SWR No. - 895

Composition of Leachates from Actual Hazardous Waste Sites, EPA 600/2-87/043
NTIS No. - PB 87-198743
SWR No. - 915

Pollutant Control - Liners
Flexible Membrane Liners in Roof Tub Exposure Test
NTIS No. - Unknown
SWR No. - 1051

Long-Term Exposure to FMLs and an Asphaltic Membrane to Hazardous Waste in One-Sided Exposure Cells
NTIS No. - Unknown
SWR No. - 1050

Liner Materials Exposed to Hazardous and Toxic Sludges-- First Interim Report, EPA 600/2-77/081
NTIS No. - PB 271013/AS
SWR No. - 458

Liners for Sanitary Landfills and Chemical and Hazardous Waste Disposal Sites, EPA 600/9-78/005
NTIS No. - PB 293335/AS
SWR No. - 499

Flue Gas Cleaning Sludge Leachate/Liner Compatibility Investigation--Interim Report, EPA 600/2-79/136
NTIS No. - PB 80-100480
SWR No. - 558

A Method for Determining the Compatibility of Hazardous Wastes, EPA 600/2-80/076
NTIS No. - PB 80-221005
SWR No. - 593

Effect of Flue Gas Cleaning Sludges on Selected Liner Materials, EPA 600/2-81/098
NTIS No. - PB 81-213365
SWR No. - 681

Potential Clogging of Landfill Drainage Systems, EPA 600/2-83/109
NTIS No. - PB 84-110550
SWR No. - 789

Laboratory Studies of Soil Bedding Requirements for Flexible Membrane Liners, EPA 600/2-84/021
NTIS No. - PB 84-141498
SWR No. - 815

Electrical Resistivity Technique to Assess the Integrity of Geomembrane Liners, EPA 600/2-84/180
NTIS No. - PB 85-122414
SWR No. - 836

Field Studies of Liner Installation Methods at Landfill and Surface Impoundments, EPA 600-2-84/168
NTIS No. - PB 85-117067
SWR No. - 809

Liner Materials Exposed to Hazardous and Toxic Wastes, EPA 600/2-84/169
NTIS No. - PB 85-121333
SWR No. - 837

Test Methods for Determining the Chemical Waste Compatibility of Synthetic Liners, EPA 600/2-85/029
NTIS No. - PB 85-182970
SWR No. - 850

Assessment of Synthetic Membrane Successes and Failures at Waste Storage and Disposal Sites, EPA 600/2-85/100
NTIS No. - PB 85-245637
SWR No. - 858

Resistance of Flexible Membrane Liners to Chemicals and Wastes, EPA 600/2-86/058
NTIS No. - PB 86-184496
SWR No. - 880

Avoiding Failure of Leachate Collection and Cap Drainage Systems, EPA 600/2-86/058
NTIS No. - PB 86-208733
SWR No. - 893

Geotextiles for Drainage, Gas Venting and Erosion Control at Hazardous Waste Sites, EPA 600/2-86/085
NTIS No. - PB 87-129557
SWR No. - 882

Evaluation of Flexible Membrane Liner Seams after Chemical Exposure and Simulated Weathering, EPA 600/2-87/015
NTIS No. - PB 87-166526
SWR No. - 925

Assessment of Techniques for In Situ Repair of Flexible Membrane Liners: Final Report, EPA 600/2-87/038
NTIS No. - PB 87-191813
SWR No. - 931

Quantification of Leak Rates Through Holes in Landfill Liners, EPA 600/2-87/062
NTIS No. - PB 87-227466
SWR No. - 920

Development of Chemical Compatibility Criteria for Assessing Flexible Membrane Liners, EPA 600/2-87/067
NTIS No. - PB 87-227310
SWR No. - 951

Manual of Procedures and Criteria for Inspecting the Installation of Flexible Membrane Liners in Hazardous Waste Facilities, EPA 600/8-87/056
NTIS No. - PB 88-131313
SWR No. - 960

Geosynthetic Design Guidance for Hazardous Waste Landfill Cells and Surface Impoundments, EPA 600/2-87/097
NTIS No. - PB 88-131263
SWR No. - 958

Freeboard Determination and Management in Hazardous Waste Surface Impoundments, EPA 600/2-88/015
NTIS No. - PB 88-243787
SWR No. - 932

Factors in Assessing the Compatibility of FML's and Waste Liquids, EPA 600/2-88/017
NTIS No. - PB 88-173372
SWR No. - 972

The Electrical Leak Location Method for Geomembrane Liners, EPA 600/2-88/035
NTIS No. - PB 88-220496
SWR No. - 987

Loading Point Puncturability Analysis of Geosynthetic Liner Materials, EPA 600/2-88/040
NTIS No. - PB 88-235544
SWR No. - 985

Technical Considerations for DeMimimis Pollutant Transport Through Polymeric Liners, EPA 600/2-88/042
NTIS No. - PB 88-238332
SWR No. - 983

Consensus Report of the AD HOC Meeting on the Service Life in Landfill Environments of Flexible Membrane Liners and other Synthetic Polymeric Materials of Construction, EPA 600/X-88/252
NTIS No. - Unknown
SWR No. - 988

Stability of Lined Slopes at Landfills and Surface Impoundments, EPA 600/2-89/057
NTIS No. - PB 90-251877
SWR No. - 1023

Fundamental Approach to Service Life of Flexible Membrane Liners's (FMLs), EPA 600/2-90/041
NTIS No. - PB 90-263856
SWR No. - 1021

Service Life of Geosynthetics in Hazardous Waste Management Facilities, EPA 600/10-91/018
NTIS No. - PB 91-162826
SWR No. - N/A

Time-Domain Reflextometry and Acoustic-Emission Monitoring Techniques for Locating Liner Failures
NTIS No. - Unknown
SWR No. - 1040

Compilation of Information Alternative Barriers for Liner and Cover Systems, EPA 600/2-91/002
NTIS No. - PB 91-141846
SWR No. - 1019

Sorption and Transport of Gases in Glassy Polymers
NTIS No. - PB 91-145151
SWR No. - 1038

Landfill Leachate Clogging of Geotextile (and Soil) Filters, EPA 600/2-91/025
NTIS No. - PB 91-213660
SWR No. - 1013

LCDR Flow from Double-Lined Landfills and Surface Impoundments, EPA 600/R-93/005
NTIS No. - PB 93-179885
SWR No. - 1114

Report on Workshop on Geosynthetic Clay Liners, EPA 600/R-93-
NTIS No. - Unknown
SWR No. - 1118

Pollutant Control - Models and Expert Systems
Verification of the Hydrologic Evaluation of Landfill Performance (HELP) Model Using Field Data, EPA 600/2-87/050

NTIS No. - PB 87-227518
SWR No. - 993

Verification of the Lateral Drainage Component of the HELP Model Using Physical Models, EPA 600/2-87/049
NTIS No. - PB 87-227104
SWR No. - 934

Evaluation of Hydrologic Models in the Design of Stable Landfill Covers, EPA 600/2-88/048
NTIS No. - PB 88-243811
SWR No. - 979

Closure Evaluation System (CES): Includes Final Cover, Vegetative Cover and Leachate Collection Systems
NTIS No. - PB 93-502870 (Software - EPA/SW/DK-93/032)
SWR No. - 1125
NTIS No. - PB 93-144533 (User's Guide - EPA/SW/DK-93/032a)
SWR No. - 1125

Flexible Membrane Liner System, (FLEX), User Guide to Version 3.0
NTIS No. - PB 93-502631 (Software - EPA/SW/DK-93/029)
SWR No. - 1125
NTIS No. - PB 93-134872 (User's Guide - EPA/SW/DK-93/029a)
SWR No. - 1125

Geosynthetic Modeling System (GM), Version 1.1
NTIS No. - PB 93-502870 (Software - EPA/SW/DK-93/031)
SWR No. - 1125
NTIS No. - PB 93-144525 (User's Guide - EPA/SW/DK-93/031a)
SWR No. - 1125

Hydrologic Evaluation of Landfill Performance (HELP) Model -- Version 3.01
NTIS No. - Unknown (User's Guide - EPA/600/R-94/168a)
SWR No. - 1125
NTIS No. - Unknown (Engineering Documentation - EPA/600/R-94/168b)
SWR No. - 1125

Pollutant Control - Cover
Assessment of Technology for Construction and Installing Cover and Bottom Liner Systems for Hazardous Waste Facilities - Volume I
NTIS No. - Unknown
SWR No. - 1042

A Study of Trench Covers to Minimize Infiltration at Waste Disposal Sites
NTIS No. - Unknown
SWR No. - 1944

Evaluating Cover Systems for Solid and Hazardous Waste, W-867
NTIS No. - PB 87-154894
SWR No. - 689

Settlement and Cover Subsidence of Hazardous Waste Landfills, EPA 600/2-85/035
NTIS No. - PB-85-188829
SWR No. - 849

Prediction/Mitigation of Subsidence Damage to Hazardous Waste Landfill Covers, EPA 600/2-87/05
NTIS No. - PB 87-175378
SWR No. - 997

Design, Construction, and Maintenance of Cover Systems for Hazardous Waste: An Engineer Guidance Document, EPA 600/2-87/039
NTIS No. - PB 87-191656
SWR No. - 929

RCRA Cover Systems for Waste Management Facilities, EPA 600/J-91/319
NTIS No. - PB 92-120435
SWR No. - N/A

Surface Impoundments
Assessment of Innovative Technologies to Detect Waste Impoundment Liner Facilities, EPA 600/2-84/041
NTIS Nò. - PB 84-157858
SWR No. - 800

Innovative Concepts for Detecting and Locating Leaks in Waste Impoundment Liner Systems: Acoustic Emission Monitoring and Time Domain Reflectometry, EPA 600/2-84/058
NTIS No. - PB 84-161819
SWR No. - 819

Covers for Uncontrolled Hazardous Waste Sites EPA 540/2-85/002
NTIS No. - PB 87-119483
SWR No. - 886

Technical Resource Documents for Landfills
Lining of Waste Impoundment and Disposal Facilities, SW-870
NTIS No. - PB 86-192796
SWR No. - 701

Evaluating Cover Systems for Solid and Hazardous Waste, SW-867
NTIS No. - PB 87-154894
SWR No. - 698

Closure of Hazardous Waste Surface Impoundments, SW-873
NTIS No. PB 87-155537
SWR No. - 704

Technical Guidance Document: Construction Quality Assurance for Hazardous Waste Land Disposal Facilities, EPA 530/SW-86/031
NTIS No. - PB 87-132825
SWR No. - 908

Geotextiles for Drainage, Gas Venting and Erosion Control at Hazardous Waste Sites, EPA 600/2-86/085
NTIS No. - PB 87-129557
SWR No. - 882

Lining of Waste Containment and Other Impoundment Facilities, EPA 600/2-88/952
NTIS No. - PB 89-129670
SWR No. - 1029

Technical Guidance Document: The Fabrication of Polyethylene FML Field Seams, EPA 530/SW-89/069
NTIS No. - PB 90-119595
SWR No. - 1005

Guidance Manual for Assuring Construction Quality for Flexible Membrane Liners
NTIS No. - Unknown
SWR No. - 1045

Technical Guidance Document: Inspection Techniques for the Fabrication of Geomembrane Field Seams, EPA 530/SW-91/051
NTIS No. - PB 92-109057
SWR No. - 1015

Technical Handbooks for Contaminated Soils
Lining of Waste Containment and Other Impoundment Facilities, EPA 600/2-88/052
NTIS No. - PB 89-129670
SWR No. - 1029

Technical Guidance Document: "Quality Assurance and Quality Control for Waste Containment Facilities," EPA 600/R-93/183
NTIS No. - 93-
SWR No. - 1120

Appendix "B"
Koerner / Geosynthetic Institute letter dated March 10, 2014

Appendix "C"
ASTM D7909-14 Standard Guide for Placement of Blind Actual Leaks during Electrical Leak Location Surveys of Geomembranes

Appendix "D"
ASTM D7240 - 06(2011) Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)

Appendix "E"
ASTM D7703 - 15 Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Lance Method

Appendix "F"
ASTM D7002 - 15 Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Puddle Method

Appendix "G"
"Assessment and Recommendations for Improving the Performance of Waste Containment Systems",
R. Bonaparte, D.E. Daniel, and R.M. Koerner, EPA/600/R-02/099,
http://www.epa.gov/nrmrl/pubs/600r02099.pdf

Appendix B

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March 10, 2014

Environmental Quality Board
P. O. Box 8477
Harrisburg, PA 17105-8477

RE: Proposed Amendments to 25 Pa-Code, Chapter 78, Subchapter C

Dear All,

We represent 72 firms and agencies dealing with the proper development and use of geosynthetic materials including "synthetic flexible liners" which are called "geomembranes" by many other organizations. Among our 18 agency members is the Pennsylvania Department of Environmental Protection with Steve Socash as our contact person… see our website at www.geosynthetic-institute.org for details. This communication has two major points which we ask you to seriously consider as you go forward with your regulations.

1. The original Subchapter C – Environmental Protection Performance Standards has a 1×10^{-7} cm/sec maximum permeability for the synthetic flexible liner being used. This is a ridiculously high value and represents a typical clay or silt soil. Geomembranes have permeabilities down to 1×10^{-13} cm/sec and should be referenced and regulated as such. The agency is confusing everyone (including the public) by having such a high value representing the liner material for all types of containment pits.
2. *The proposed January 15, 2014 regulation banning the use of lined pits is completely inappropriate.* A properly lined geomembrane pit manufactured with polymers such as high density polyethylene (HDPE) will outlast steel storage tanks by decades.[*] Attesting to this established fact is that <u>all</u> landfills and surface impoundments for nonhazardous and hazardous solid and liquid wastes are lined accordingly. Their performance has been documented over time and with the use of double lined systems allows for the development of an "action leakage rate" for ultimate security of adjacent land and waters.[**] Your proposed banning of geomembrane lined pits for flowback and

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[*] "Lifetime Prediction of Laboratory UV Exposed Geomembranes," by R. M. Koerner, G.R. Koerner, Y. G. Hsuan and W. K. Wong, GRI Report #42, January 3, 2013, 37 pgs.

[**] "Assessment and Recommendations for Improving the Performance of Waste Containment Systems," by R. Bonaparte, D. E. Daniel and R. M. Koerner, EPA/600/R-02/099, December 2002, 950 pgs.

production drilling waters flies in the face of the entire solid and liquid waste technology as practiced by the U.S. EPA and every state agency (including Pennsylvania) as well.

As a Pennsylvania resident my entire life and working with the PaDEP since its original founding, I ask you to re-consider your stance insofar as pit lining for flowback and production waters at drilling sites and operations. As you likely know the potential for contamination of these drilling fluids pales into insignificance in comparison to hazardous, and even nonhazardous, leachate from the solid and liquid waste industries.

Very truly yours,

Robert M. Koerner, Ph.D., P.E., NAE
Director Emeritus
Geosynthetic Institute

Attachment: resumé

APPENDIX C

Designation: D7909 − 14

Standard Guide for Placement of Blind Actual Leaks during Electrical Leak Location Surveys of Geomembranes[1]

This standard is issued under the fixed designation D7909; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide is for placing blind actual leaks in geomembranes before performing an electrical leak location survey. The geomembranes can be bare (not covered) or can be covered with water or moist soil.

1.2 This guide is intended to serve as an additional quality control/quality assurance (QC/QA) measure to ensure that leaks through the geomembrane are detectable, site conditions are proper for leak location surveys, and a valid and complete leak location survey is performed. Because various leak location practitioners use a wide variety of equipment to perform these surveys and have a wide range of expertise, placement of blind actual leaks by the owner or owner's representative helps ensure that the leak location survey is being performed correctly and completely.

1.3 Placing blind actual leaks can also assist in determining whether or not the site conditions permit the flow of electric current through leaks, which is necessary for detecting leaks using electrical methods.

1.4 For clarification, this guide is in addition to the typical placement of the artificial or actual leaks placed as described in the relevant ASTM International standards for the various leak location methods.

1.5 Placing blind actual leaks should be done with the consent and knowledge of all involved parties and specifically the "owner" of the geomembrane. Geomembranes are typically purchased and installed by dedicated geosynthetic installers who "own" the geomembrane until the ownership gets transferred to the end user. A project meeting should be set up with the owner, the consultant, the geosynthetic installers, and the leak location contractor. The intention to use blind leaks should be clearly stated by the owner or consultants or both and the scope and number to be placed should be understood by all parties. The consultant should broadly identify to the lining contractor a location that can be easily repaired after the test. It is critical that all actual blind holes be included on the liner documentation and repair record drawing.

1.6 Leak location surveys can be used on geomembranes installed in basins, ponds, tanks, ore and waste pads, landfill cells, landfill caps, and other containment facilities. The procedures are applicable for geomembranes made of electrically insulating materials. (**Warning**—The electrical methods used for geomembrane leak location could use high voltages resulting in the potential for electrical shock or electrocution. This hazard might be increased because operations might be conducted in or near water. In particular, a high voltage could exist between the water or earth material and earth ground or any grounded conductor. These procedures are potentially very dangerous and can result in personal injury or death. The electrical methods used for geomembrane leak location should be attempted only by qualified and experienced personnel. Appropriate safety measures shall be taken to protect the leak location operators as well as other people at the site.)

1.7 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4439 Terminology for Geosynthetics

D6747 Guide for Selection of Techniques for Electrical Detection of Leaks in Geomembranes

D7002 Practice for Leak Location on Exposed Geomembranes Using the Water Puddle System

D7007 Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials

[1] This test method is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.10 on Geomembranes.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D7240 Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)

D7703 Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Lance System

3. Terminology

3.1 *Definitions:* For general definitions used in this guide, refer to Terminology D4439.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *artificial leak, n*—for the purposes of this guide, an artificial leak is an electrical simulation of a leak in a geomembrane during the leak detection sensitivity setup.

3.2.2 *blind actual leak, n*—for the purposes of this guide, a blind actual leak is a circular hole in the geomembrane intentionally placed by the owner or owner's representative to ensure that the site conditions are suitable for an electrical leak location survey and that a valid electric leak location survey is performed in a location unknown to the leak location practitioner.

3.2.2.1 *Discussion*—A blind actual leak is not a leak used to determine the leak detection sensitivity parameters.

3.2.3 *electrical leak location, n*—method that uses electrical current or electrical potential to detect and locate leaks in electrically isolating geomembranes.

3.2.4 *leak, n*—for the purposes of this guide, a leak is any unintended opening, perforation, breach, slit, tear, puncture, crack, or seam breach in electrically isolating geomembranes.

3.2.4.1 *Discussion*—Significant amounts of liquids or solids may or may not flow through a leak. Scratches, gouges, dents, or other aberrations that do not completely penetrate the geomembrane are not considered to be leaks.

3.2.5 *leak detection sensitivity, n*—smallest size leak that the leak location equipment and survey methodology are capable of detecting under a given set of conditions.

3.2.5.1 *Discussion*—The leak detection sensitivity specification is usually stated as a diameter of the smallest leak that can be reliably detected.

4. Significance and Use

4.1 Geomembranes are used as low-permeability barriers to control liquids from leaking from landfills, ponds, and other containments. The liquids may contain contaminants that, if released, can cause damage to the environment. Leaking liquids can also erode the subgrade. Leakage can result in product loss or otherwise prevent the installation from performing its intended containment purpose. For these reasons, it is desirable that the geomembrane have as little leakage as practical.

4.2 Geomembrane leaks can result even when the quality of the subgrade preparation, the quality of the material placed on the geomembrane, and the quality of the workmanship are not deficient.

4.3 Electrical leak location methods are an effective final quality assurance (QA) measure to locate previously undetected leaks in electrically insulating geomembranes. Practices for these implementations are contained in Guide D6747 and Practices D7002, D7007, D7240, and D7703.

4.4 It is important to realize that the detection of leaks depends not only on the capabilities of the leak location equipment, procedures, and experience of the leak location practitioner but also on local site conditions that are not under the control of the leak location practitioner. In particular, to detect a leak, there shall be an electrical conduction path through the leak and through the materials above and below the leak to allow sufficient electrical current through the leak for detection. For some site conditions, such as a leak not making contact with the subgrade, dry geotextile, or geocomposite above or below the leak; dry materials above or below the leak; degree of isolation between the materials above and below the geomembrane; and other factors, may preclude the detection of leaks. Therefore, the use of a properly placed blind actual leak is also a test of site preparations and conditions.

4.5 It is not necessarily proper to conclude that, if a blind actual leak is not detected, a leak location survey, using the proper relevant ASTM International standard, has no validity. Real leaks that have more favorable site conditions and larger leaks may still be detected.

4.6 The importance of blind actual leaks is to provide an additional measure to assess whether the site conditions are proper for a leak location survey and that the electric leak location survey is performed correctly and completely. The use of blind actual leaks provides: (*1*) a check that the equipment is operating properly, (*2*) a test for proper survey coverage, and (*3*) a check that all survey data (results) have been assessed to confirm a proper survey has been done. These all result in a high likelihood that significant-sized leaks are detected.

5. Procedural Guidance for Placement of Blind Actual Leaks

5.1 The fact that blind actual leak(s) will be installed in the geomembrane, and who will install the blind leak(s), who will survey the locations of the blind leak(s), and finally who will repair the blind actual leaks should be clearly described in the project specifications and understood by all affected parties so responsibilities and costs involved are fully understood by all affected parties. For the geomembrane leak location survey and use of blind actual leaks to be decisive, the project specifications should also specify the relevant ASTM International standard procedures to be used to perform the geomembrane leak location survey (see 2.1).

5.2 A realistic test of the leak detection sensitivity should be performed and documented as part of every leak location survey. The leak detection sensitivity of the leak location system via an actual or artificial leak is typically used according to the corresponding standard practices for the various leak location systems. The procedures for installing the actual leak holes for determining the leak detection sensitivity listed in the corresponding ASTM procedure can be used with the modifications described in 5.3 to place blind actual leaks.

5.3 The various electrical leak location practices all specify the use of actual leaks and procedures for making those actual leaks to determine the survey parameters and verify proper system operation. Leak detection is dependent upon the site conditions at each leak. Site conditions that affect leak detection sensitivity (particularly for surveys with earth materials on the geomembrane, to some degree with surveys on bare geomembranes) include:

5.3.1 Having adequate moisture throughout the overburden material and near subgrade,

5.3.2 Moisture in the leak,

5.3.3 The presence of dry insulating materials such as geotextile or geonet in contact with the leak,

5.3.4 Contact of the geomembrane with the overburden and subgrade,

5.3.5 Degree of isolation of the overburden from earth ground or the conducting material under the geomembrane, and

5.3.6 The composition of the material in contact with the liner (large stones may bridge a leak).

5.4 Because of these varying site conditions, detecting a leak of the same size as the actual leak used to determine the leak detection sensitivity as specified in the ASTM International standards (see 2.1) could be problematic. Better leak detection sensitivity will be obtained at some locations, and worse leak detection sensitivity will be obtained at other locations. The specific guidelines for installing blind actual leaks are:

5.4.1 The preferred blind actual leaks are to be constructed by drilling a hole with a minimum diameter of 1.0 mm for exposed geomembranes (1.4 mm for a blind actual leak for a water covered leak detection survey and 6.4 mm for a blind actual leak for an earthen covered leak detection survey) that is to be tested at the time of geomembrane installation. The blind actual leaks shall be installed the same day as the geomembrane installation, and as early as practical before the geomembrane leak location survey is performed so that the blind test leak will be exposed to the same conditions of rainfall, condensation, consolidation, and equilibrium as the rest of the geomembrane in the installation. If the blind actual leaks cannot be installed the same day as during geomembrane placement and installation, the diameters of the blind actual leak shall be increased to twice the above-mentioned diameters. Specifically, the blind actual leak diameter would result into using a diameter of 12.8 mm for geomembranes that are to be covered with earth materials, 2.8 mm for geomembranes that are to be covered with water, and 2.0 mm for bare geomembranes.

5.4.2 For a double geomembrane system or underlying geosynthetic clay liner (GCL), procedures shall ensure that the drill bit does not damage the secondary geomembrane or GCL. The hole shall be drilled, and the drill bit moved forward and backward in the hole so the geomembrane material is removed rather than just displaced. (**Warning**—Because of the shock or electrocution hazard that may be involved with high voltage, do not attempt to drill the blind actual leak with the excitation power supply on or connected.)

5.4.3 The blind actual leaks are to be installed by the owner or a representative of the owner without revealing the locations to the leak location practitioner or others.

5.4.4 The locations of the blind actual leaks shall be documented using appropriate land-surveying methods so the blind actual leaks can be located for future repair.

5.4.5 The blind actual leaks shall be put in representative locations and not on wrinkles, areas of bridging, in fusion seams, or other areas where the geomembrane is not in contact with the subgrade. They should not be placed within 5 m of the edge of the survey area.

5.4.6 The blind actual leaks shall be backfilled with a compaction representative of the rest of the installation. Ensure that any cavity made by the drill in the subgrade under the blind actual leak is filled with soil.

5.4.7 The number of placed blind actual leaks should be consistent with the size and complexity of the overall installation, as well as with the purposes for which the blind actual leaks are installed. The owner or owner's representative should consider the cost of installing, surveying, documenting, and repairing the blind actual leaks and the fact that a repair weld or patch of inferior integrity will replace an otherwise intact geomembrane.

5.5 In summary, for the leak location survey to detect the intentionally placed blind actual leaks successfully, the blind actual leaks should have conductivity through the openings; otherwise, they may not be detected. If the owner or owner's representative has their own independent leak location equipment, the blind actual leaks could be verified as they are being placed.

5.6 As a courtesy to the leak location survey practitioner, the owner or owner's representative should mention at the start of the survey that a blind actual leak has been placed in accordance with this guide.

5.7 This guide is not a replacement of the existing ASTM procedures governing leak location surveys. In summary, all the leak location equipment, personnel, and procedures should demonstrate the ability to detect the actual or artificial leak before commencing the leak location survey as described in the relevant ASTM International standards (see 2.1).

6. Guidance if Blind Actual Leak is Detected

6.1 If the blind actual leak is detected, it should be treated as any other detected leak and the relevant ASTM standard practice should be followed including documenting and reporting and, whenever specified, testing for additional leaks in the near vicinity.

7. Guidance if Blind Actual Leak is Not Detected

7.1 If the leak location survey practitioner does not detect a blind actual leak after surveying an area where the blind actual leak was placed, then the owner or owner's representative should mention that a blind actual leak was not detected. The leak location survey practitioner shall review the survey data to determine if the blind actual leak signal is indicated in the survey data. If a leak signal is discernible in the data, all of the data should be reviewed to determine if any other leak signals were missed. In addition, the leak location practitioner and the representative of the owner shall confirm that the survey successfully completed the leak detection sensitivity tests per the corresponding ASTM International procedure and that the survey was performed according to the ASTM International procedure.

7.2 If the blind actual leak was not detected (even after review of the survey data and confirming that the survey was performed properly per the relevant ASTM standard procedure) then the representative of the owner will show the leak location practitioner the position of the undetected blind actual leak and a leak location survey will be conducted to cover that area. If no leak signal is present in the repeat data, then the following potential conditions should be considered for each blind actual leak:

7.2.1 Subgrade restrictions (conductivity, moisture content, and so forth);

7.2.2 Proximity to survey boundary;

7.2.3 Geosynthetics underneath or above the geomembrane;

7.2.4 Uncovered material restrictions (waves, wrinkles, and so forth);

7.2.5 Cover material restrictions (conductivity, water saturation, and so forth);

7.2.6 Water requirement (depth necessary, quantity of water needed, bottom slope);

7.2.7 Proximity to protruding/penetrating accessories (pipes, steel bars, access platforms, ladders, concrete structure, and so forth). If so, the blind actual leak was not placed per the procedures of the relevant ASTM International standard;

7.2.8 The blind actual leak did not completely breach the thickness of the geomembrane; and

7.2.9 The blind actual leak was not in contact with the subgrade.

7.3 If it can be demonstrated that the blind actual leak was not detectable because of the considerations in 7.2.1 – 7.2.9 or other limitations and a detailed check with the leak location equipment shows that there is no electrical conductivity through the blind actual leak, then the blind actual leak (with its selected specific diameter) was, in fact, never detectable with that particular leak detection setup or site conditions. The cause of not being able to detect the blind leak should be investigated. If poor site conditions preclude the detection of the blind leak, then the site conditions should be modified in order to increase survey sensitivity. If modification of the site conditions enables detection of the blind leak, then the leak location survey should be repeated in any areas surveyed prior to modifying the site conditions. If it is determined that poor site conditions preclude the performance of a survey at the desired level of sensitivity and the site conditions cannot be altered, then the survey can nevertheless continue; however, with the knowledge that the desired level of sensitivity will be less than desired. In the extreme case where the site conditions preclude the performance of a survey on any size leak, such as a survey requested on non-conductive subgrade, then a leak location survey cannot be performed, and the failure to detect the blind actual leak does not indicate a shortcoming of the leak location survey. A report detailing the cause of the poor site conditions should be submitted in place of the leak location final report.

7.4 If the survey is ongoing for multiple days, it is recommended to review relevant ASTM International procedures to assure that the leak detection sensitivity test was implemented correctly. For example, the survey spacing could be optimized in accordance with relevant ASTM International standards (see 2.1). Alternatively, the size of the placed blind actual leak in the remainder of the survey can be increased to account for poor site conditions, with the exception where the site conditions preclude the performance of a survey altogether.

7.5 If it is deemed that the placed blind actual leak was not affected by the considerations in 7.2.1 – 7.2.9 or other limitations and the leak location practitioner cannot demonstrate functionality of the leak location equipment even though all components of the electrical leak path are proven to be sufficiently conductive for a survey and the survey is not affected by poor boundary conditions, then the blind actual leak was, in fact, never detectable with that particular leak detection equipment, and the failure to detect it indicates a shortcoming of the leak location practitioner. In that case, consideration should be given to repeating the leak location survey with different equipment or a different leak location practitioner, or both, until all actual blind leaks are successfully located. Responsibility for the cost of additional surveys will be in accordance with project contract requirements.

8. Keywords

8.1 artificial leak; blind actual leak; electrical leak location; geomembrane; leak detection; leak location

APPENDIX D

Designation: D 7240 – 06

Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)[1]

This standard is issued under the fixed designation D 7240; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard is a performance-based practice for using the spark test to electrically locate leaks in exposed geomembranes with an insulating layer that are in intimate contact with a conductive layer. For clarity, this document uses the term 'leak' to mean holes, punctures, tears, cuts, cracks and similar breaches over the partial or entire area of an installed geomembrane (as defined in 3.2.3).

1.2 This test method can be used on exposed geomembranes installed in basins, ponds, tanks, ore and waste pads, landfill cells, landfill caps, and other containment facilities. This standard is applicable for geomembranes in direct and intimate contact with a conductive surface or with a conductive layer integrally included.

1.3 **SAFETY WARNING:** The electrical methods used for geomembrane leak location use high voltage, low current power supplies, resulting in the potential for electrical shock. The electrical methods used for geomembrane leak location should be attempted by only qualified and experienced personnel. Appropriate safety measures must be taken to protect the leak location operators as well as other people at the site.

1.4 *This standard does not purport to address all of the safety and liability concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 4439 Terminology for Geosynthetics

D 6747 Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes

3. Terminology

3.1 Definition of terms applying to this test method appear in Terminology D 4439.

3.2 *Definitions:*

3.2.1 *electrical leak location, n*—a method which uses electrical current or electrical potential to detect and locate leaks.

3.2.2 *geomembrane, n*—an essentially impermeable membrane used with foundation, soil, rock, earth or any other geotechnical engineering related material as an integral part of a man made project, structure, or system.

3.2.3 *leak, n*—For the purposes of this document, a leak is any unintended opening, perforation, breach, slit, tear, puncture or crack. Significant amounts of liquids or solids may or may not flow through a leak. Scratches, gouges, dents, or other aberrations that do not completely penetrate the geomembrane are not considered to be leaks.

Leaks detected during surveys have been grouped into three categories:

- Holes – round shaped voids with downward or upward protruding rims
- Tears – linear or circular voids with irregular edge borders
- Linear cuts – linear voids with neat close edges

3.2.4 *intimate contact, n*—for the purposes of this document, intimate contact is when a conductive layer is in direct contact with the insulating geomembrane, and there are no gaps between the two layers to prohibit the flow of current.

3.2.5 *leak detection sensitivity, n*—The smallest size leak that the leak location equipment and survey methodology are capable of detecting under a given set of conditions. The leak detection sensitivity specification is usually stated as a diameter of the smallest leak that can be reliably detected.

3.2.6 *wand, n*—for the purposes of this document, any rod that has a conductive brush that is attached to a power source to initiate the spark test.

[1] This practice is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.10 on Geomembranes.

Current edition approved Jan. 1, 2006. Published February 2006.

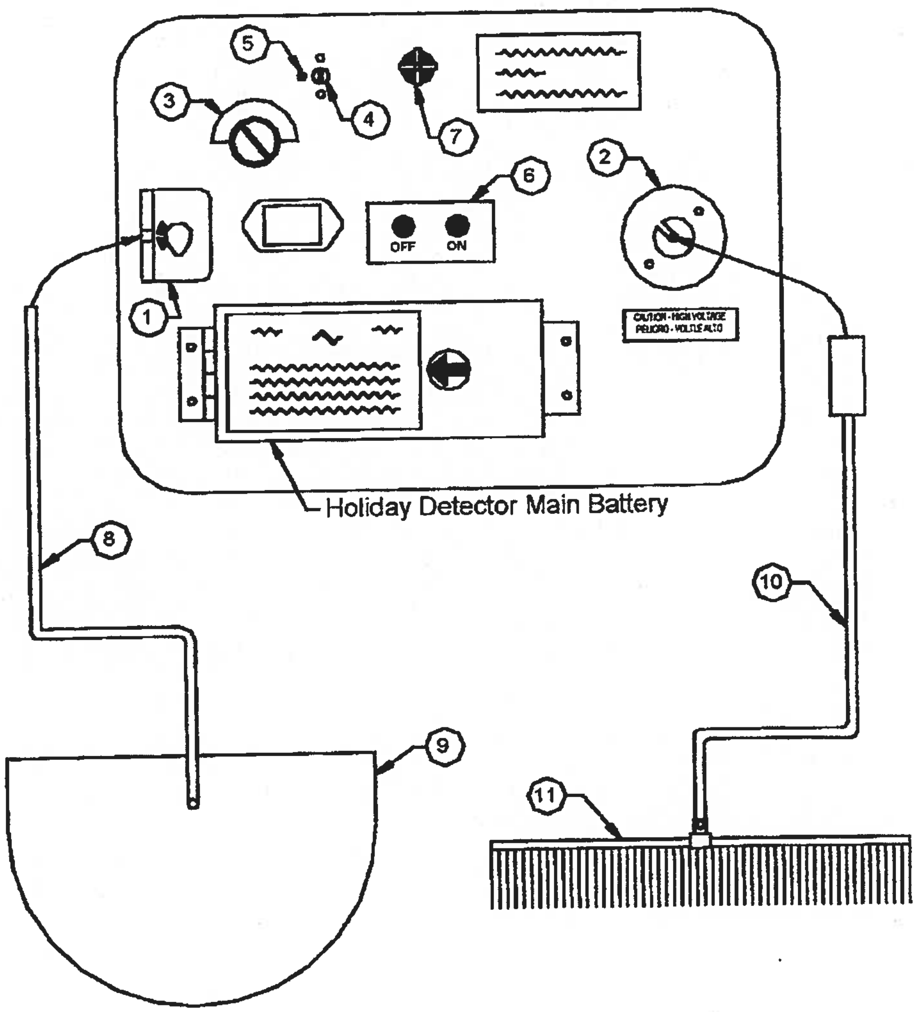
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

4. Summary of Practice

4.1 The principle of this electrical leak location method is to use a high voltage pulsed power supply to charge a capacitor formed by the underlying conductive layer, the non-conductive layer of the geomembrane and a coupling pad. The area is then swept with a test wand to locate points where the capacitor discharges through a leak. Once the system senses the discharge current, it is converted into an audible alarm.

4.2 *General Principles*

4.2.1 Fig. 1 shows a wiring diagram of the coupling pad, power supply and test wand for the electrical leak location method of a geomembrane with a lower conductive layer. Once all necessary connections are made, the pad is placed on the upper surface of the geomembrane. The nonconductive (insulating layer(s)) of the geomembrane act as a dielectric in a capacitor which stores electrical potential across the geomembrane.



Legend For Spark Tester Diagram

1. Ground Terminal
2. High Voltage Terminal
3. Sensitivity Dial
4. Voltage Dial (# x 1,000 = Wand Voltage)
5. Voltage Adjusting Screw (Remove plug first)
6. Main Power Switches
7. Alarm Buzzer
8. Ground Lead
9. Electrically Conductive Grounding Pad
10. High Voltage Lead
11. Wand

FIG. 1 Wiring Diagram of the Equipment Required for Spark Testing Geomembrane in Intimate Contact With a Conductive Surface.

4.2.2 A grid, test lanes or other acceptable system should be used to ensure that the entire area is tested with the test wand.

4.2.3 Either a hand held wand or a larger wand mounted to an all terrain vehicle may be used. Generally a hand held wand is a more efficient method unless the area is quite large and flat.

4.3 *Preparations and Measurement Considerations*

4.3.1 Testing must be performed on geomembranes that are clean and dry. For geomembrane covered by water or soils, other test procedures, such as described in Guide D 6747 will have to be used for testing the geomembrane.

4.3.2 Fusion and extrusion welds must be tested using state of the practice nondestructive methods such as air channel test and vacuum box test, respectively. If the test wand gets too close to the edge of the conductive geomembrane, the electrical charge can arc to the back side of the conductive geomembrane and may cause a false positive.

5. Significance and Use

5.1 Geomembranes are used as barriers to prevent liquids from leaking from landfills, ponds, and other containments. For this purpose, it is desirable that the geomembrane have as little leakage as practical.

5.2 The liquids may contain contaminants that if released can cause damage to the environment. Leaking liquids can erode the subgrade, causing further damage. Leakage can result in product loss or otherwise prevent the installation from performing its intended containment purpose.

5.3 Geomembranes are often assembled in the field, either by unrolling and welding panels of the geomembrane material together in the field, or unfolding smaller flexible geomembranes in the field.

5.4 In exposed geomembrane applications, geomembrane leaks can be caused by poor quality of the subgrade, accidents, poor workmanship, and carelessness.

5.5 Electrical leak location methods are an effective final quality assurance measure to locate previously undetected leaks.

6. Procedure

6.1 Before beginning a leak survey, the equipment must be checked to ensure it is in working order. The power source should have a range of voltage from 15,000 to 35,000 volts. A wider voltage range is acceptable but the maximum is typically 35,000 volts. The test wand may be up to 6 feet wide with a brass brush. The coupling pad should be connected as shown in Fig. 1.

6.2 Once the equipment has been checked and wired properly, a trial test must be performed. A puncture (deliberate defect) should be introduced in a test piece of geomembrane. The deliberate defect should be approximately 1 mm in diameter. The test piece of geomembrane must be of sufficient size to enable movement of the brush at normal testing speed over the deliberate defect without touching the edges of the test piece or the coupling pad.

6.3 Place the test piece on a large scrap of geomembrane or on the installed geomembrane with the conductive side down. The deliberate defect and the coupling pad should both be on the large scrap piece of geomembrane.

6.3.1 Turn on the test unit and adjust the voltage and sensitivity to maximum settings.

6.3.2 Sweep the test piece with the wand ensuring that the test wand remains in contact with the geomembrane surface. It is important this be done at normal speeds.

6.3.3 Ensure the audible alarm sounds when the brush passes over the deliberate defect. If the alarm does not sound, recheck the connections and retest. If the alarm sounds prior to passing over the damage, turn the sensitivity down and retest the area. The minimum voltage required is site specific and will vary with atmospheric and other site conditions.

6.3.4 At a minimum, the equipment should be checked before testing begins and after any shut down of an hour or more. In the event a test reveals the equipment is not working properly, the entire area spark tested since the last passing check of the equipment will have to be retested to assure it was spark tested with working equipment.

6.4 Field testing may be performed by marking a predetermined grid, using a two person team or another acceptable method.

6.5 The leak location survey shall be conducted using procedures whereby the test wand contacts every point on the surface of the geomembrane being surveyed for leaks – neglecting the edge effects.

NOTE 1—Welded seams cannot be tested using this method. They must be tested by test procedures appropriate for such items – this standard practice applies only to the sections of geomembrane in between the welded edges.

NOTE 2—Actual survey speed must be no greater than survey speed used during trial test.

7. Reporting

7.1 The leak location survey report shall contain the following information

- Description of the survey site
- Description of test apparatus
- Climatic conditions
- Thickness of geomembrane
- Survey methodology
- Results of system functionality and calibration test
- Location, type and size of leaks
- Repair technique of detected leaks
- Map of the surveyed areas

8. Keywords

8.1 geomembrane; leak detection; leak location; electrical leak location method; construction quality assurance

APPENDIX E

Designation: D7703 – 11

Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Lance System[1]

This standard is issued under the fixed designation D7703; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard is a performance-based practice using the water lance system, a electrical method for detecting leaks in exposed geomembranes. For clarity, this document uses the term "leak" to mean holes, punctures, tears, knife cuts, seam defects, cracks and similar breaches in an installed geomembrane.

1.2 This standard can be used for geomembranes installed in basins, ponds, tanks, ore and waste pads, landfill cells, landfill caps, canals, and other containment facilities. It is applicable for geomembranes made of materials such as polyethylene, polypropylene, polyvinyl chloride, chlorosulfonated polyethylene, bituminous geomembrane, and any other electricallyinsulating materials. This standard may not be applicable for locating geomembrane leaks where the proper preparations have not been made during the construction of the facility.

1.3 **Warning—The electrical methods used for geomembrane leak location could use high voltages, resulting in the potential for electrical shock or electrocution. This hazard might be increased because operations might be conducted in or near water. In particular, a high voltage could exist between the water or earth material and earth ground, or any grounded conductor. These procedures are potentially VERY DANGEROUS, and can result in personal injury or death. The electrical methods used for geomembrane leak location should be attempted only by qualified and experienced personnel. Appropriate safety measures must be taken to protect the leak location operators as well as other people at the site.**

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4439 Terminology for Geosynthetics

D6747 Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes

D7007 Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials

3. Terminology

3.1 For general definitions used in this document, refer to D4439.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *artificial leak, n*—an electrical simulation of a leak in a geomembrane.

3.2.2 *current, n*—the flow of electricity or the flow of electric charge.

3.2.3 *electrode, n*—the conductive plate that is placed in earth or in the material under the geomembrane or a conductive element typically placed inside the water reservoir.

3.2.4 *electrical leak location, n*—a method which uses electrical current or electrical potential to detect and locate leaks.

3.2.5 *leak, n*—for the purposes of this document, a leak is any unintended opening, perforation, breach, slit, tear, puncture, crack, or seam breach. Significant amounts of liquids or solids may or may not flow through a leak. Scratches, gouges, dents, or other aberrations that do not completely penetrate the geomembrane are not considered to be leaks. Leaks detected during surveys have been grouped into five categories:

holes—round shaped voids with downward or upward protruding rims.

tears—linear or areal voids with irregular edge borders.

linear cuts—linear voids with neat close edges.

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[1] This practice is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.10 on Geomembranes.

Current edition approved June 1, 2011. Published July 2011. DOI: 10.1520/D7703-11.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

seam defects—area of partial or total separation between sheets.

burned through zones—voids created by melting polymer during welding.

3.2.6 *leak detection sensitivity, n*—the smallest leak that the leak location equipment and survey methodology are capable of detecting under a given set of conditions. The leak detection sensitivity specification is usually stated as a diameter of the smallest leak that can be reliably detected.

3.2.7 *water stream, n*—for the purposes of this document, a continuous stream of water between the water lance and the geomembrane that creates a conduit for current to flow through any leaks.

3.2.8 *water lance, n*—for the purposes of this document, a probe (lance) incorporating two electrodes that directs a solid stream of water through a single nozzle mounted at the end.

4. Summary of Practice

4.1 *The Principle of the Electrical Leak Location Method Using the Water Lance System*:

4.1.1 The principle of the electrical leak location method is to place a voltage across a geomembrane and then locate areas where electrical current flows through leaks. ASTM Standard D6747 is a guide for the selection of the various implementations of the method.

4.1.2 Fig. 1 shows a diagram of the electrical leak location method of the water lance system for exposed geomembranes. One output of an electrical excitation power supply is connected to an electrode placed in the water reservoir; a pump sends this charged water to the water lance (Fig. 2) that jets the water in a solid stream on top of the geomembrane. The other output of the power supply is connected to an electrode placed in electrically conductive material under the geomembrane.

4.2 *Leak Location Surveys of Exposed Geomembrane Using the Water Lance System*:

4.2.1 The water lance detection system usually consists of a single nozzle mounted at the end of a probe (lance) (Fig. 2) that directs a solid stream of water onto a geomembrane, and an electronic detector assembly as shown in Fig. 3. A pressurized water source, usually from a small reservoir on top of the liner, or from a tank truck isolated from ground parked at higher elevation, is connected to the water lance using a plastic or rubber hose.

4.2.2 Direct current power supplies (often a 12 or 24 volt battery) have been used for leak location surveys.

4.2.3 For leak location surveys of exposed geomembrane, the solid water stream (not a spray) is moved systematically over the geomembrane area to locate the points where the electrical current flow increases as the charged water from the water lance contacts the oppositely charged conductive media under the geomembrane through a hole.

4.2.4 The voltage drop signal between the two electrodes in the water column in the water lance is typically connected to an electronic detector assembly that converts the electrical signal to an audible signal that increases in pitch and amplitude as the leak signal increases (Fig. 3).

4.2.5 When a leak signal is detected, the location of the leak is then marked or located relative to fixed points.

4.2.6 The leak detection sensitivity can be very good for this technique. Leaks smaller than 1 mm in diameter are routinely found, including leaks through seams in the geomembrane.

4.3 *Preparations and Measurement Considerations*:

4.3.1 Proper field preparations and other measures must be implemented to assure an electrical connection to the conductive material directly below the geomembrane is in place.

4.3.2 There must be a conductive material directly below the geomembrane being tested. Typically a properly-prepared subgrade will have sufficient conductivity. Under proper conditions and preparations, geosynthetic clay liners (GCLs) can be adequate as conductive material. There are some conductive geotextiles with successful field experience which can be installed beneath the geomembrane to facilitate electrical leak survey (that is, on dry subgrades, or as part of a planar drainage geocomposite).

4.3.3 Measures should be taken to perform the leak location survey when geomembrane wrinkles are minimized.

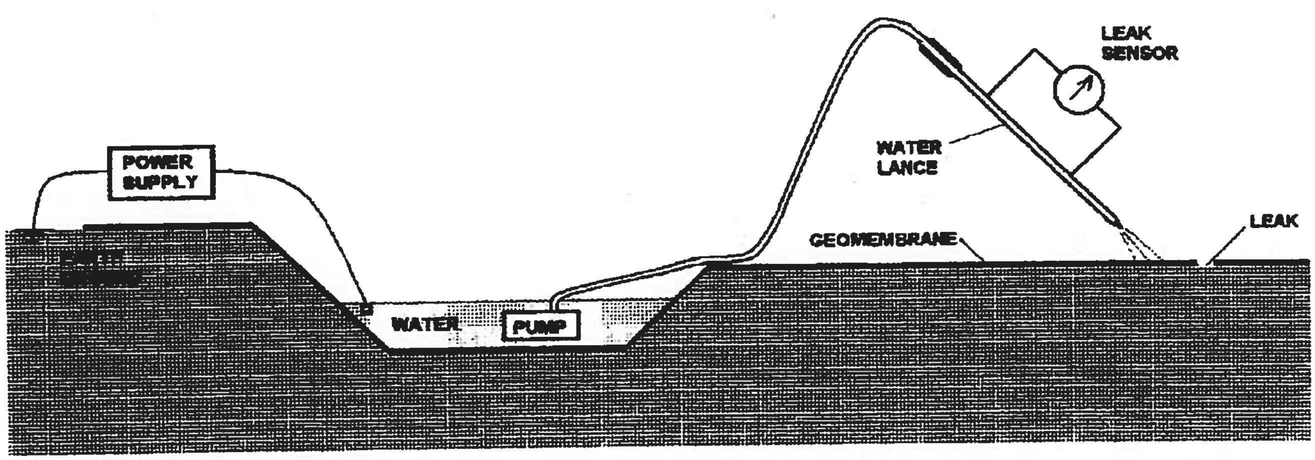

FIG. 1 Diagram of the Electrical Leak Location Method for Surveys with Water Lance on Exposed Geomembrane

FIG. 1 Diagram of the Electrical Leak Location Method for Surveys with Water Lance on Exposed Geomembrane

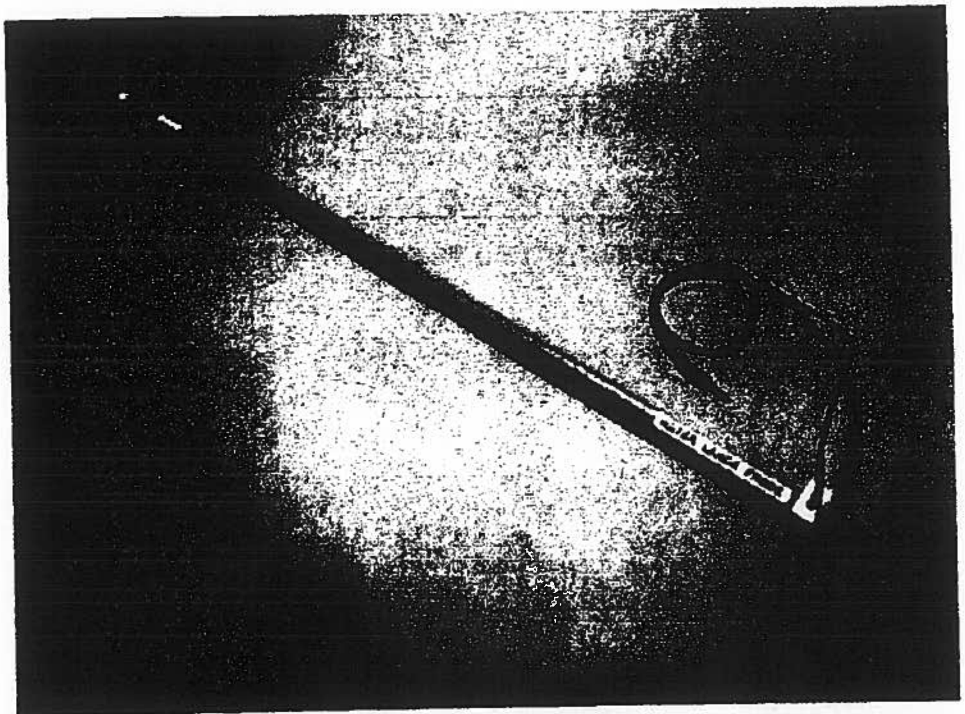

FIG. 2 Typical water lance

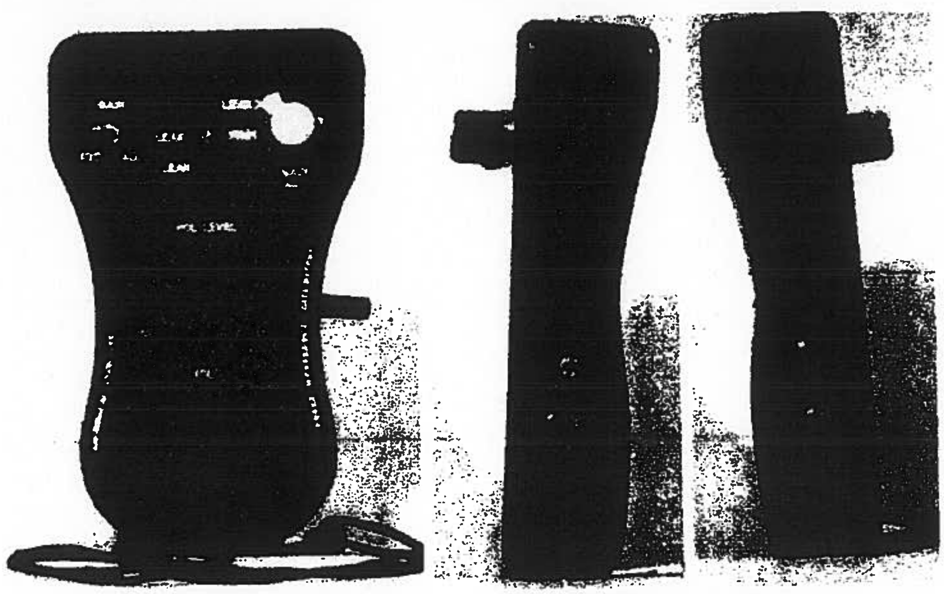

FIG. 3 Photographs of Water Lance Electronic Detector Assembly

NOTE 1—The leak location survey could be conducted at night or early morning when wrinkles are minimized. Sometimes wrinkles can be flattened by personnel walking or standing on them as the survey progresses. Condensation may provide a conductive layer under the geomembrane.

4.3.4 Conversely, surveys should not be made in areas with bridging geomembrane. The survey of areas with minor bridging might be accomplished when the geomembrane is warmer.

4.3.5 For lining systems comprised of two geomembranes with only a geonet or geotextile/geonet/geotextile composite (geocomposite) between them, to make the method feasible a conductive layer such as a conductive geotextile must be installed under the geomembrane or integrated into the geocomposite.

4.3.6 For best results, conductive paths such as metal pipe penetrations, pump grounds, and batten strips on concrete should be isolated or insulated from the water lance on the geomembrane. These conductive paths conduct electricity and mask nearby leaks from detection.

4.3.7 Depending on specific construction practices and site conditions, other preparations and support may still be needed to successfully perform the leak location survey.

4.3.8 The system characteristics are presented in Table 1.

5. Significance and Use

5.1 Geomembranes are used as barriers to prevent liquids from leaking from landfills, ponds, and other containments. For this purpose, it is desirable that the geomembrane have as little leakage as practical.

5.2 The liquids may contain contaminants that if released can cause damage to the environment. Leaking liquids can erode the subgrade, causing further damage. Leakage can result in product loss or otherwise prevent the installation from performing its intended containment purpose.

5.3 Geomembranes are often assembled in the field, either by unrolling and welding panels of the geomembrane material together in the field, or unfolding flexible geomembranes in the field.

5.4 Geomembrane leaks can be caused by poor quality of the subgrade, poor quality of the material placed on the geomembrane, accidents, poor workmanship, and carelessness. D7007 describes the electrical methods for locating leaks in Geomembranes Covered with Water or Earth Materials.

5.5 Electrical leak location methods are an effective and proven quality assurance measure to locate previously undetected leaks and check the integrity of a liner.

6. Procedure

6.1 A realistic test of the leak detection sensitivity shall be performed and documented as part of the leak location survey. An actual or artificial leak can be used. The leak location equipment and procedures should demonstrate the ability to detect the artificial or actual leak when the water stream is passed over the leak in the geomembrane.

6.2 *Artificial Leak*—An artificial leak may consist of the cut end of an insulated solid core wire, or an exposed metal disc mounted on a plastic plate and connected to a wire (Fig. 4). The assembly is placed on the surface of the liner. The wire is connected to an electrode in the subgrade such that current will flow through the subgrade for a distance equivalent to the distance between the center of the liner and the negative (ground) applied potential electrode.

6.3 *Actual Leak*—If an actual leak is used, which is technically preferred, it shall be constructed by drilling a 1 mm diameter hole in the installed geomembrane that is to be tested. For double geomembranes, measures must be taken to ensure that the secondary geomembrane is not damaged. The hole must be drilled at least 600 mm away from the edge of the geomembrane. The distance between the hole and the electrode in contact with the conductive media under the geomembrane should be greater than the distance between the center of the liner and the electrode in contact with the conductive media under the geomembrane. The hole should be drilled, and the drill bit reciprocated in the hole so the geomembrane material is removed rather than displaced.

6.4 The excitation power supply and the water supply shall be turned on, and the water stream shall be moved over the artificial or actual leak at a speed equal to the desired

TABLE 1 Characteristics of the Water Lance Leak Detection Technique

geomembranes	Bituminous, CSPE, CPE, EIA, fPP, HDPE, LLDPE, LDPE, PVC, VLDPE,	applicable	
	EPDM, GCL		not applicable
	exposed	applicable	
	covered		not applicable
GCL	GCL		not applicable
characteristics	set up time and leak detection sensitivity test	1 to 3 h	
	measurement time	instantaneous	
	average survey speed (horizontal surface)	900 m^2 per hour per operator	
seams	all types: welded, tape, adhesive, glued and other	applicability is project specific	
	Seams of patches		not usually applicable
junctions	at synthetic pipes and accessories	applicability is project specific	
	at permanent structure	applicability is project specific	
survey	during construction phase (installation of GM)	applicable	
	after installation (exposed)	applicable	
	after soil covering		not applicable
	presence of large wrinkles and waves		not applicable
	slopes		
	during the service life (if exposed)	applicable	
	electrical isolated conductive structures	applicable	
	presence of bridging		not applicable
climate	sunny, temperate, warm	applicable	
	rainy weather, freezing weather		not applicable
leak detected	size of 1 mm and larger	applicable	
	discrimination between multiple leaks	applicable	

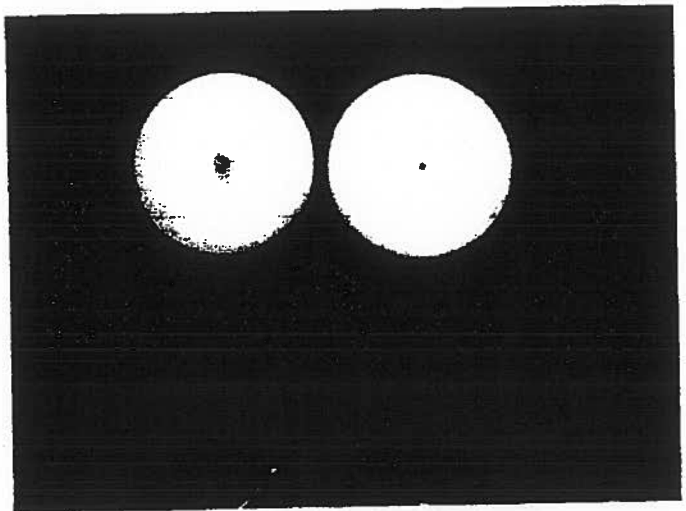

FIG. 4 Photographs of Artificial Leaks

production survey speed. Ideally testing shall progress from areas of lower elevation to areas of higher elevation

6.5 The resulting signal as the stream passes over the hole shall be distinctly and consistently greater than the background level. The applied potential across the liner and the signal meter controls shall be adjusted to achieve such a signal.

6.6 The leak location survey shall be conducted using the same water distribution speed as that used for the leak detection sensitivity test. The survey shall not be performed any farther from the electrode in contact with the conductive media under the geomembrane than the distance between the leak detection sensitivity test and the electrode in contact with the conductive media under the geomembrane.

6.7 Periodic testing of the integrity of the electrical circuit is recommended. It is recommended to check the integrity of the electrical circuit every 15 to 20 minutes by contacting the conductive media under the geomembrane with the water stream or by using an extra electrical cable well-connected to the conductive media under the geomembrane. At a minimum, this check shall be conducted at the beginning and end of each day of survey. If the equipment fails to pass the periodic test, then the area surveyed with that set of equipment in the period since the previous successful periodic test shall be repeated.

7. Report

7.1 The leak location survey report shall contain the following information:

7.1.1 Description of the survey site,

7.1.2 Climatic conditions,

7.1.3 Climatic conditions,

7.1.4 Liner system layering,

7.1.5 Description of the leak location method,

7.1.6 Survey methodology,

7.1.7 Identification of equipment and operators,

7.1.8 Results of artificial or actual leak sensitivity test,

7.1.9 Results of periodic sensitivity test,

7.1.10 Specific conditions of survey,

7.1.11 Location, type and size of detected leaks, and

7.1.12 Map of the surveyed areas showing the approximate locations of the leaks.

8. Keywords

8.1 electrical leak location method; geomembrane; leak detection

APPENDIX F

Designation: D 7002 – 03

Standard Practice for Leak Location on Exposed Geomembranes Using the Water Puddle System[1]

This standard is issued under the fixed designation D 7002; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard is a performance-based practice for electrical methods for detecting leaks in exposed geomembranes. For clarity, this document uses the term "leak" to mean holes, punctures, tears, knife cuts, seam defects, cracks and similar breaches in an installed geomembrane (as defined in 3.1.5).

1.2 This standard can be used for geomembranes installed in basins, ponds, tanks, ore and waste pads, landfill cells, landfill caps, canals and other containment facilities. It is applicable for geomembranes made of materials such as polyethylene, polypropylene, polyvinyl chloride, chlorosulfonated polyethylene, bituminous geomembrane, and any other electrically-insulating materials.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 4439 Terminology for Geosynthetics

D 6747 Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes

3. Terminology

3.1 *Definitions:*

3.1.1 *artificial leak, n*—an electrical simulation of a leak in a geomembrane.

3.1.2 *electrodes, n*—the conductive plate that is placed in earth ground or in the material under the geomembrane or a conductive structure, such as a copper manifold, that is placed in the water puddle on the geomembrane.

3.1.3 *electrical leak location, n*—a method which uses electrical current or electrical potential to detect and locate leaks.

3.1.4 *geomembrane, n*—an essentially impermeable membrane used with foundation, soil, rock, earth or any other geotechnical engineering related material as an integral part of a man made project, structure, or system.

3.1.5 *leak, n*—for the purposes of this document, a leak is any unintended opening, perforation, breach, slit, tear, puncture, crack, or seam breach. Significant amounts of liquids or solids may or may not flow through a leak. Scratches, gouges, dents, or other aberrations that do not completely penetrate the geomembrane are not considered to be leaks. Leaks detected during surveys have been grouped into five categories:

3.1.5.1 *holes*—round shaped voids with downward or upward protruding rims.

3.1.5.2 *tears*—linear or areal voids with irregular edge borders.

3.1.5.3 *linear cuts*—linear voids with neat close edges.

3.1.5.4 *seam defects*—area of partial or total separation between sheets.

3.1.5.5 *burned through zones*—voids created by melting polymer during welding.

3.1.6 *leak detection sensitivity, n*—the smallest leak that the leak location equipment and survey methodology are capable of detecting under a given set of conditions. The leak detection sensitivity specification is usually stated as a diameter of the smallest leak that can be reliably detected.

3.1.7 *current, n*—the flow of electricity or the flow of electric charge.

3.1.8 *water puddle, n*—for the purposes of this document, a water puddle is a small pool of water being contained and pushed by a squeegee installed on the leak location system.

3.1.9 *squeegee, n*—for the purposes of this document, a squeegee is a device used to contain and push water on top of an exposed geomembrane. It may consist of a handle and a transverse piece at one end set with a strip of leather or rubber.

3.1.10 *metalized geotextile, n*—a geotextile incorporating metallic strips that can conduct electrical current.

4. Summary of Practice

4.1 *The Principle of the Electrical Leak Location Method Using the Water Puddle System:*

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[1] This practice is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.10 on Geomembranes.

Current edition approved Dec. 1, 2003. Published December 2003.

4.1.1 The principle of the electrical leak location method is to place a voltage across a geomembrane and then locate areas where electrical current flows through discontinuities in the geomembrane and at seams.

4.1.2 Fig. 1 show a diagram of the electrical leak location method of the water puddle system for exposed geomembranes. One output of an electrical excitation power supply is connected to an electrode placed in a water puddle created on top of the geomembrane. The other output of the power supply is connected to an electrode placed in electrically conductive material under the geomembrane.

4.1.3 Measurements are made using an electrical current measurement system, the magnitude of the current being related to the size of the leak. An electronic assembly is usually used to produce an audio tone whose frequency is proportional to the current flow.

4.2 *Leak Location Surveys of Exposed Geomembrane Using the Water Puddle System*:

4.2.1 The water puddle detection system usually consists of a horizontal water spray manifold with multiple nozzles that spray water onto a geomembrane, a squeegee device to push the resultant puddle of water, and a handle assembly as shown in Fig. 2. A pressurized water source, usually from a tank truck parked at higher elevation, is connected to the spray manifold using a plastic or rubber hose. Figs. 3 and 4 show one example of such an apparatus.

4.2.2 Direct current power supplies (usually a 12 or 24 volt battery) have been used for leak location surveys. An alternating current (output requirement of 12 to 30 volt AC) could be used.

4.2.3 For leak location surveys of exposed geomembrane, the water puddle created is pushed systematically over the geomembrane area to locate the points where the electrical current flow increases.

4.2.4 The signal from the probe is typically connected to an electronic detector assembly that converts the electrical signal to a detector and an audible signal that increases in pitch and amplitude as the leak signal increases.

4.2.5 When a leak signal is detected, the location of the leak is then marked or measured relative to fixed points.

4.2.6 The leak detection sensitivity can be very good for this technique. Leaks smaller than 1 mm in diameter are routinely found, including leaks through seams in the geomembrane.

4.2.7 The survey rate depends primarily on the manifold and squeegee width and the presence of wrinkles and waves in the geomembrane.

4.3 *Preparations and Measurement Considerations*:

4.3.1 There must be a conductive material below the geomembrane being tested. Leak location survey of geomembrane have been conducted with a conductivity of a subgrade equivalent to sand with moisture greater than 0.7 % (by weight). A properly-prepared subgrade typically will have sufficiently conductivity. Under proper conditions and preparations, geosynthetic clay liners (CGLs) can be also adequate.

4.3.2 Measures should be taken to perform the leak location survey when geomembrane wrinkles are minimized. For flexible geomembranes, sometimes the wrinkles can be flattened by personnel walking on them immediately in front of the survey. For surveys with wrinkles in rigid geomembranes, the leak location survey should be conducted at night or early morning.

4.3.3 For lining systems comprised of two geomembranes with only a geonet or geocomposite between them, the method is not applicable. For lining systems comprised of two geomembranes separated by a metalized geotextile, the method is applicable.

4.3.4 For best results, conductive paths such as metal pipe penetrations, pump grounds, and batten strips on concrete should be isolated or insulated from the water puddle on the geomembrane. These conductive paths conduct electricity and mask nearby leaks from detection.

4.3.5 The system specifications are presented in Table 1.

5. Significance and Use

5.1 Geomembranes are used as barriers to prevent liquids from leaking from landfills, ponds, and other containments. For this purpose, it is desirable that the geomembrane have as little leakage as practical.

5.2 The liquids may contain contaminants that if released can cause damage to the environment. Leaking liquids can erode the subgrade, causing further damage. Leakage can result in product loss or otherwise prevent the installation from performing its intended containment purpose.

5.3 Geomembranes are often assembled in the field, either by unrolling and welding panels of the geomembrane material together in the field, or unfolding flexible geomembranes in the field.

5.4 Geomembrane leaks can be caused by poor quality of the subgrade, poor quality of the material placed on the geomembrane, accidents, poor workmanship, and carelessness.

5.5 Electrical leak location methods are an effective quality assurance measure to locate previously undetected or missed leaks and check the integrity of a liner.

6. Practices for Surveys with Water Puddle System

6.1 A realistic test of the leak detection sensitivity should be performed and documented as part of the leak location survey. An actual or artificial leak can be used. The leak location equipment and procedures should be demonstrated to be able to detect the artificial or actual leak when water puddle is passed over the leak on the geomembrane.

6.2 *Artificial Leak*—If an artificial leak is used, it shall be constructed by drilling a 1 mm diameter hole in approximately the center of a piece of geomembrane. The piece of geomembrane should have a width of at least twice the width of the squeegee, and a length of at least four times the width of the squeegee. The hole should be drilled, and the drill bit reciprocated in the hole so the geomembrane material is removed rather than displaced. The artificial leak shall be placed on a subgrade that is prepared to be the same as the subgrade under the actual geomembrane. When surveying leak detection on existing containment facilities, a geomembrane sample equivalent to the liner installed should be used.

6.3 *Actual Leak*—If an actual leak is used, it shall be constructed by drilling a 1 mm diameter hole in the installed geomembrane that is to be tested. For double geomembranes,

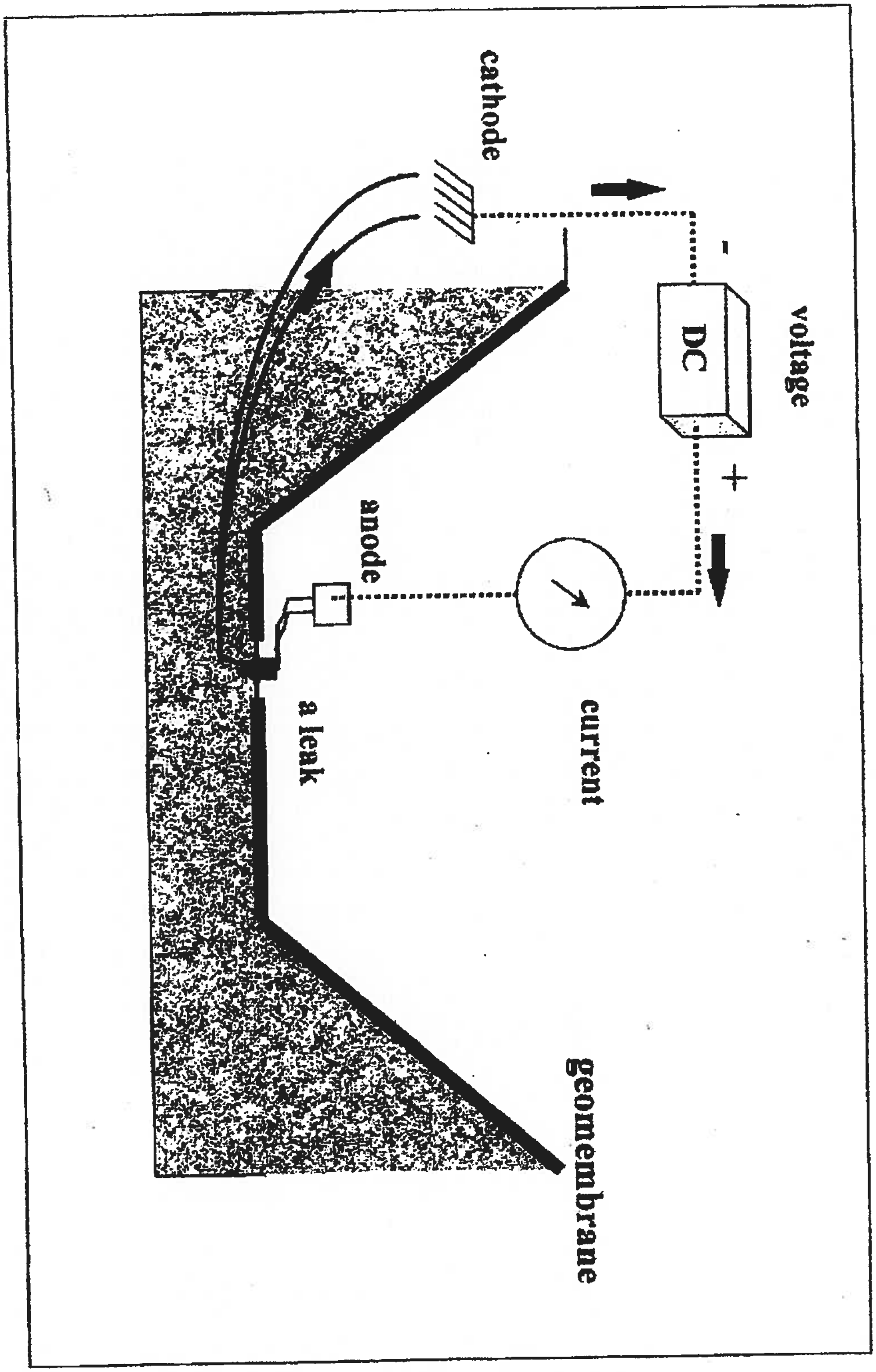

FIG. 1 Diagram of the Electrical Leak Location Method for Surveys with Water Puddle on Exposed Geomembrane

measures must be taken to ensure that the secondary geomembrane is not damaged. The hole must be drilled at least the

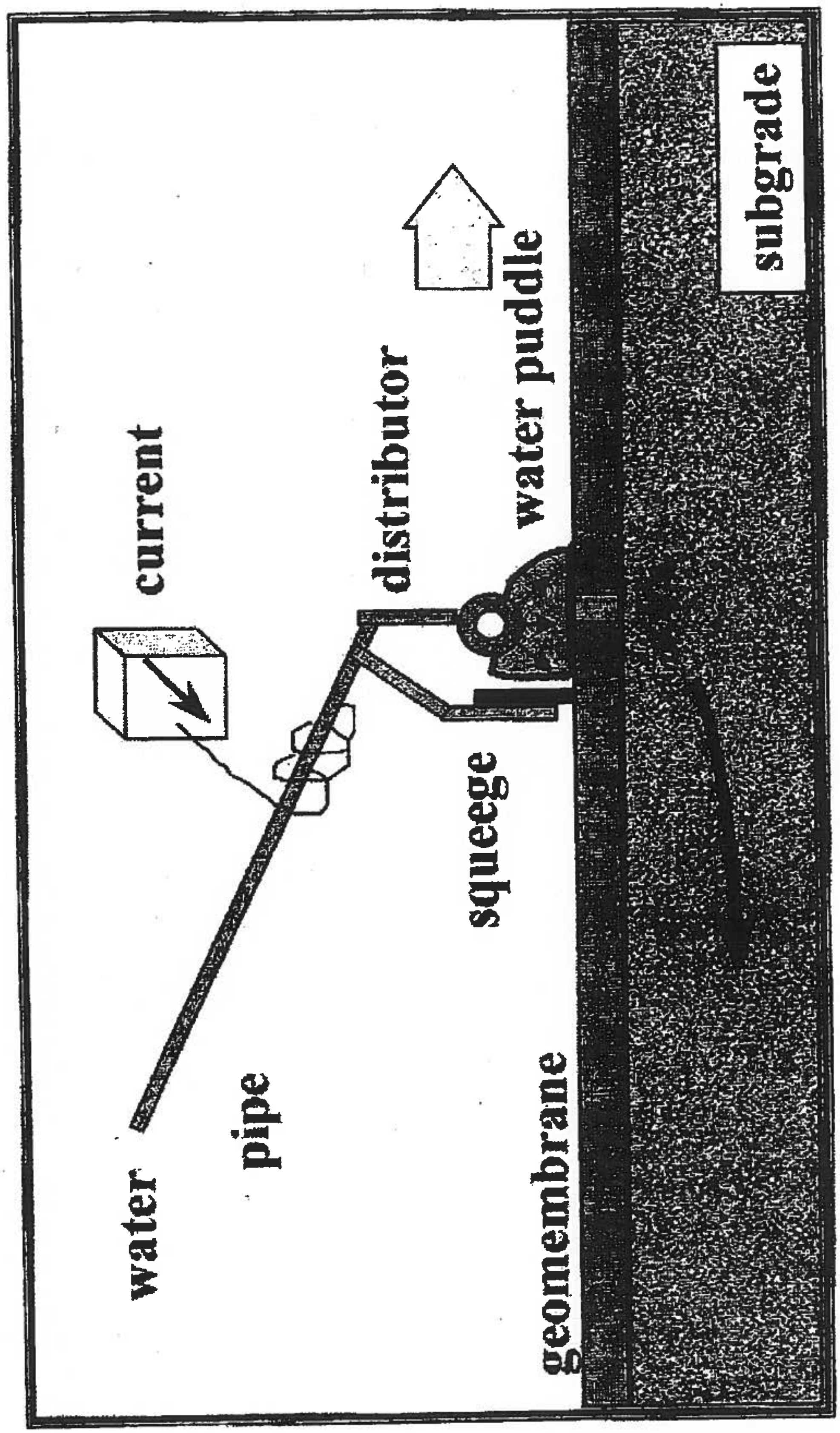

FIG. 2 Diagram of Electrical Leak Water Puddle System

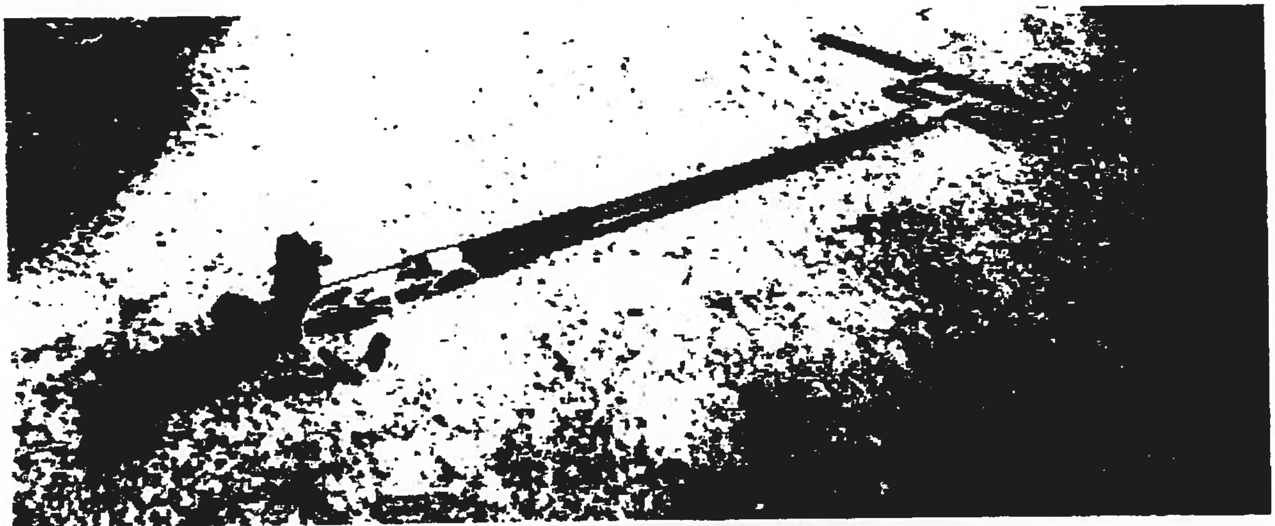

FIG. 3 Photograph of a Water Puddle Leak Location Equipment

FIG. 4 Photograph of Leak Location Equipment

width of the squeegee from the edge of the geomembrane. The hole should be drilled, and the drill bit reciprocated in the hole so the geomembrane material is removed rather than displaced.

6.4 The excitation power supply and the water supply shall be turned on, and the water puddle detection system shall be pushed over the artificial or actual leak at a speed equal to the desired production survey speed.

6.5 If the resultant signal is at least 10 percent of the full scale reading of the detector electronics, the leak detection equipment and procedures shall be considered to be successfully demonstrated.

6.6 The leak location survey shall be conducted using the same water puddle detection system speed as that used for the calibration.

6.7 Periodic testing of the integrity of the electrical circuit is recommended. It is recommended to check every 15 to 20 min the integrity of electrical circuit by contacting (touching) the subgrade with the equipment squeegee unit or by using an extra electrical cable well-connected to the subgrade. As a minimum, this check shall be conducted at the beginning and end of each day of survey. If the equipment fails to pass the leak detection sensitivity test, then the area surveyed with that set of equipment in the period since the previous leak detection sensitivity test shall be repeated.

7. Report

7.1 The leak location survey report shall contain the following information:

TABLE 1 Specifications—Water Puddle Leak Detection Techniques

geomembranes	HDPE, VLDPE, PVC, fPP, bituminous, CSPE, CPE	✓	applicable
	EPDM, GCL	X	not applicable
	exposed	✓	applicable
	covered	X	not applicable
characteristics	training time		1 day
	set up time and calibration time		1 to 3 h
	measurement time		instantaneous
	leak location time		10 min max
	subgrade moisture (by weight)		equivalent to sand with > 0.7 %
	average survey speed (horizontal surface)		500 m^2 per hour per operator
	power supply		12 or 24 volts DC or AC
seams	all types: welded, tape,adhesive, glued and other	✓	applicable: project specific
junctions	at synthetic pipes and accessories	✓	applicable: project specific
	at permanent structure	✓	applicable: project specific
survey	during construction phase (installation of GM)	✓	applicable
	after installation (exposed)	✓	applicable
	after soil covering	X	not applicable
	presence of large wrinkles and waves	X	not applicable
	slopes	✓	applicable: project specific
	desiccated subgrade (conductivity equivalent to sand with < 0.7 % moisture)	X	not applicable
	during the service life (if exposed)	✓	applicable
	electrical isolated conductive structures	✓	applicable
climate	sunny, temperate, warm	✓	applicable
	rainy weather, freezing weather	X	not applicable
leak detected	size of 1 mm and larger	✓	applicable
	discrimination between multiple leaks	✓	applicable

7.1.1 Description of the survey site,

7.1.2 Climatic conditions,

7.1.3 Type and thickness of geomembrane,

7.1.4 Liner system layering,

7.1.5 Description of the leak location method,

7.1.6 Survey methodology,

7.1.7 Identification of equipments and operators,

7.1.8 Results of artificial leak test,

7.1.9 Specific conditions of survey,

7.1.10 Location, type and size of detected leaks, and

7.1.11 Map of the surveyed areas.

8. Keywords

8.1 electrical leak location method; geomembrane; leak detection

Washington

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400 Market Street
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April 29, 2015

Proposed Regulations for Oil and Gas Surface Activities (Amendments to 25 Pa. Code Chapter 78, Subchapter C) and Rules And Regulations, Title 25— Environmental Protection, Department Of Environmental Protection [25 PA. Code CHS. 78 and 78a] Environmental Protection Performance Standards at Oil and Gas Well Sites

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Information on Environmental Protection and Structural Integrity with Geosynthetic Systems

Introduction

In response to the recent publication of the Draft Final Rulemaking: Environmental Protection Performance Standards at Oil and Gas Well Sites, **GSE offers the following additional comments and information (including attached appendices):**

GSE (www.gseworld.com) compliments the Pennsylvania Department of Environmental Protection (PA-DEP) and the Pennsylvania Environmental Quality Board (PA-EQB) for the statements and inclination to require geosynthetic lined facilities designed to protect the groundwater from potential contamination in the processes of oil and gas exploration and extraction.

However, GSE would like to point our deficiencies in the approach, language and standards used to attempt to accomplish this.

GSE recommends that the regulations put forth require the use of a composite liner system (geomembrane and geosynthetic clay liner) as this system has been demonstrated (by PA-DEP and the United States Environmental Protection Agency (USEPA)) to be the most effective barrier methodology, regardless of the classification of the materials contained (hazardous, non-hazardous or designated for beneficial re-use, solid, liquid or mixtures). This comment contains additional references to USEPA reports and studies as well as test data generated, using USEPA protocols that support the effectiveness of composite liner systems and their components. Lacking the construction of a composite liner system, as the existing proposed regulations exist currently, the language and complete lack of application of existing standards for inspection of the synthetic liner are likely to result in environmental contamination and do not use current technology and as such, are well out of date.

Statement of proposed requirement(s)
In 25 Pa. Code Chapter 78 (and (a)), the proposed regulations discuss the requirements of synthetic liner systems as follows:

Section § 78.57. Control, storage and disposal of production fluids.

(vi) The pit is impermeable and is lined with a synthetic flexible liner or alternate material that has a coefficient of permeability of no greater than 1 x 10-7 cm/sec. The liner shall be of sufficient strength and thickness to maintain the integrity of the liner. The thickness of a synthetic liner shall be at least 30 mils. Adjoining sections of liners shall be sealed together in accordance with the manufacturer's directions to prevent leakage.

(vii) The physical and chemical characteristics of the liner shall be compatible with the waste and the liner is resistant to physical, chemical and other failure during transportation, handling, installation and use. Liner compatibility shall satisfy EPA Method 9090, Compatibility Test for Wastes and Membrane Liners, or other documented data approved by the Department.

(viii) The pit shall be constructed so that the liner sub base is smooth, uniform and free of debris, rock and other material that may puncture, tear, cut, rip or otherwise cause the liner to fail. The liner sub base and subgrade shall be capable of bearing the weight of the material above the liner without settling in an amount that will affect the integrity of the liner. If the pit bottom or sides consist of rock, shale or other material that may cause the liner to leak, a sub base of at least 6 inches of soil, sand or smooth gravel, or a sufficient amount of an equivalent material shall be installed over the area as the sub base for the liner.

(ix) Prior to placing brine or other fluids in the pit, the operator shall inspect the liner and correct all damage or imperfections that may cause the liner to leak.

Further, as a general statement of intent, PADEP publishes the following statement on their website:

Containment Practices Inadequate containment practices pose a potential threat of pollution to the waters of the commonwealth. The containment provisions included in this proposed regulation were carefully developed based on DEP's inspection and field experience. Act 13 includes new containment systems and practices requirements for unconventional well sites. There are many options for containment that the oil and gas industry uses and is constantly developing improvements for, so DEP must be on the forefront of the curve.

Respondent comments
With all due respect, if it is the goal of the PADEP and the PA-EQB to be "on the forefront of the curve" the language and requirements of the proposed regulations require significant changes. While this may appear to be a very strong statement, the good news is that the PADEP has an excellent track record in the use of composite liners, geosynthetic materials and proper application of their usage and possesses significant expertise in this regard. Further, there is an institution located within the commonwealth that is the preeminent global leader in the use and application of these materials. That is the Geosynthetic Institute located in Folsom, Pennsylvania. The directors of the Institute have commented on the proposed regulations. Their comments are included with this commentary and deserve a serious review and integration into the regulatory process.

GSE would like to ensure that the PADEP and the PA-EQB are aware of all pertinent information related to the effective use of geosynthetic materials for waste containment. The Geosynthetic Institute (Drs. Robert and George Koerner, Folsom, PA) website contains an index of the U.S. EPA documents that are related to the use of geosynthetics. The complete list is attached as an Appendix "A". Further, a link to the webpage is here: http://www.geosynthetic-institute.org/epa.html. Clearly, geosynthetic materials have been well examined and proven to be effective.

GSE would like to state our concurrence with the opinions and information previously supplied to the docket by The Geosynthetic Institute in their letter and commentary dated March 10, 2014 (Appendix "B"). In the interest of brevity, GSE does not re-supply the technical reference materials listed in that document and available on the Geosynthetic Institute website.

However, based on the technical information presented therein, GSE recommends that the Proposed Rule be revised to use current practices for inspection and the verification of the geosynthetic liner system integrity

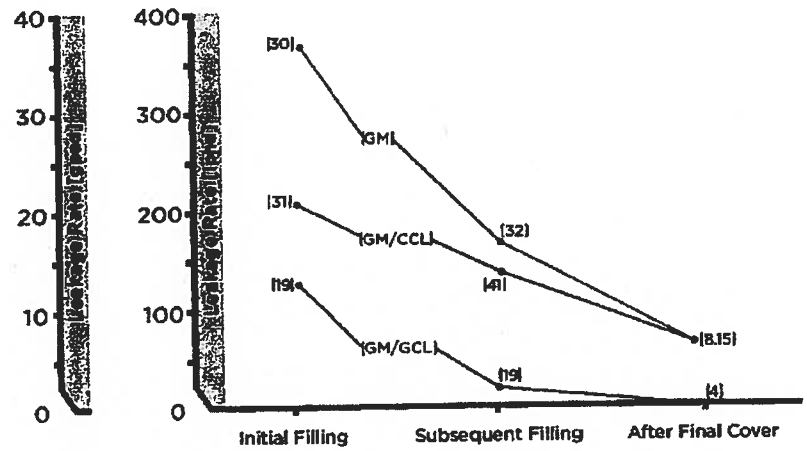
The regulations currently call out a synthetic liner and require the liner be inspected. To wit: "the operator shall inspect the liner and correct all damage or imperfections that may cause the liner to leak". This requirement is very poorly stated and presents several issues. Who is qualified to make such an inspection? What should the inspection entail? What level of damage is allowable?

The responder wishes to bring to the attention of the PA EQB that there are well established protocols for determining the integrity and barrier performance of synthetic liners. Multiple ASTM (American Standard Test Methods) methods exist and are detailed in the appendices C through F. These well established, documented and reliably demonstrated protocols exist to establish the integrity of the synthetic liner and assure protection of the environment. There are also systems in place that can provide continuous monitoring of geosynthetic liner systems. A standard that does not require the usage of these systems and protocols cannot be considered to reflect current engineering and technical practices and certainly does not meet the stated intention of the standard to "on the forefront of the curve".

In another topic, GSE also wishes to point out to the Board the historical performance of system recommends described as a 'composite liner', consisting of two components: An upper component consisting of a minimum 30-mil flexible membrane liner (FML), AND a lower component consisting of either at least a two-foot layer of compacted soil with a hydraulic conductivity of no more than 1 x 10^{-7} cm/s, or a geosynthetic clay liner (GCL) containing at least 0.75 lb/ft^2 of sodium bentonite. While a two foot layer of clay may not be technically and economically feasible for these systems, the use of a GCL within a composite system is extremely effective, in fact, historically demonstrated to be the best available technology.

The prescriptive liner system described under US EPA Subtitle D (40 CFR Part 258) is a composite liner with two components: an upper component consisting of a minimum 30-mil flexible membrane liner (FML, also commonly called a geomembrane), and a lower component consisting of at least a two-foot layer of compacted soil with a hydraulic conductivity of no more than 1 x 10-7 cm/sec. This system, utilizing a geomembrane /synthetic liner and a clay component has been extremely successful over the past several decades at containment of liquids (and solids) with significant potential for environmental damage. This has been evaluated on multiple occasions. Appendix "B" lists one document of particular interest titled "Assessment and Recommendations for Improving the Performance of Waste Containment Systems" by R. Bonaparte, D.E. Daniel, and R.M. Koerner, US EPA publication: EPA/600/R-02/099 (Appendix G) One figure illustrating data from this document illustrates the relative performance of various systems, a geomembrane / synthetic liner alone, a composite liner consisting of a geomembrane / synthetic liner with compacted clay and a composite liner consisting of a geomembrane / synthetic liner with geosynthetic clay liner. Leakage rates are plotted over time expressed as the stages of the containment site.

[→] LANDFILL LINER SYSTEM PERFORMANCE



[Ref: 2002 Bonaparte, Daniel and Koerner, U.S. EPA]

Clearly composite liners, particularly those utilizing a GCL have a successful track record in containment applications. Also clear is the fact that a geomembrane/synthetic liner alone is the least effective system.

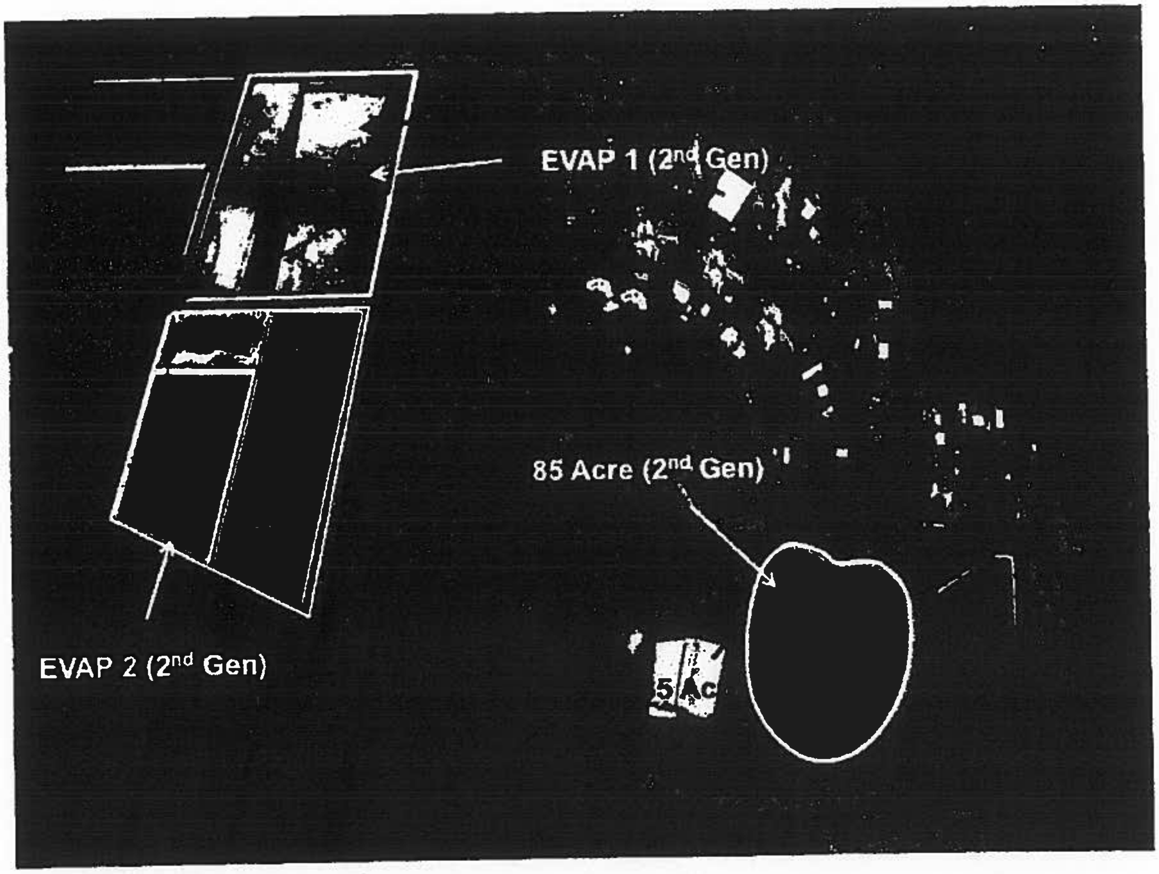
GSE would like to offer the following references to demonstrate and support our stated recommendation and position

The paper "A Statistical Approach to Minimizing Landfill Leakage" presented at the SWANA (Solid Waste Association of North America (www.swana.org)), Washington D.C. Conference by Abigail Beck in 2012 clearly demonstrates the effectiveness of liner integrity surveys and illustrate the statistical calculated leakage rates that should be expected on the basis of the technologies used. (Appendix H)

The paper "Geomembrane Liner Failure; modeling of its influence on contaminate transfer" by Vladimir Nosko and Nathalie Touze-Foltz does an excellent job of capturing and analyzing the damage that can occur to geosynthetic systems and the consequences of that damage in resulting leakage and contamination. (Appendix I)

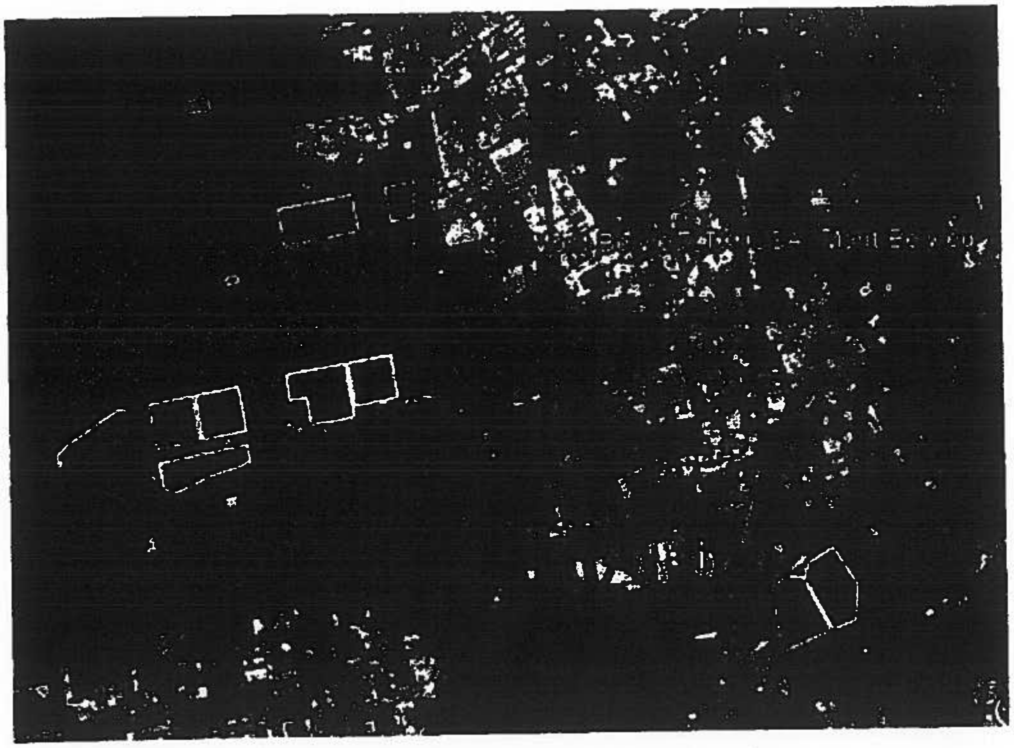
The paper "Available Technologies to Approach Zero Leaks" by Abigail Beck presented at this year's Geosynthetics 2015 conference in Portland Oregon demonstrates the current standard of practice for these geosynthetic systems; a goal of zero leakage that is usually attainable with proper practices. (Appendix J)

These systems and practices have had extensive use in the industry. The Palo Verde Nuclear Generating Station outside of Phoenix, Arizona USA is pictured here. This facility has utilized millions of square feet of composite liner systems and utilized liner integrity surveys to verify the integrity of the installed containment cells with no significant leakage or contamination issues. 60 mil GSE Leak Location White geomembrane is used here.



Palo Verde Nuclear Generating Station outside of Phoenix, Arizona USA

Another of many of these installations is a series of brine storage ponds located near Mount Belvieu, Texas. Pictured below this site also utilizes GSE Leak Location Geomembrane and liner integrity surveys of the types described above have been done regularly on these units. These sites are permitted by the state of Texas and operate with maximum action leakage rates of 20 gallons/acre/day (187 liters/hectare/day). In practice these ponds have a near zero leakage performance. They are very similar in design to the option chosen voluntarily by Range Resources Inc. – a composite liner with a leak detection system and a secondary liner, thickness of the geomembrane layers are 60 mils and the system(s) are verified by liner integrity surveys during and after their construction. 60 mil GSE Leak Location White geomembrane is used here.



Mount Belvieu, Texas Brine ponds

Conclusion
The benefits and successes of utilizing geosynthetic barriers in containment systems has been well documented by the technical materials supplied by GSE contained and further referenced here. Geosynthetics have been tested and successfully evaluated in great detail over a long period of use in a very wide range of applications by PADEQ and pioneered, investigated and for the last several decades improved by the Geosynthetic Institute.

GSE recommends that the existing technology and protocols for geosynthetic liner integrity testing and verification be used to assure that these systems perform as desired and contain the liquids that they are designed to and capable of containing.

GSE recommends that the Proposed Rule require a 'composite liner' consisting of two components: An upper component consisting of a minimum 60-mil High Density Polyethylene geomembrane liner, and a lower component consisting of a geosynthetic clay liner. GSE recommends that the integrity of the geomembrane and barrier /lining system be required to be verified by one of the many ASTM protocols established explicitly for this purpose.

GSE thanks the Commonwealth for the consideration provided. GSE and our staff are more than willing to respond to any additional inquiry on this or other related topics.

Sincerely,

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Appendix "A"

Geosynthetic Institute

U. S. Environmental Protection Agency

U. S. Environmental Protection Agency (EPA)

U. S. Environmental Protection Agency (EPA) Research Publications which involve Geosynthetic Materials (published from July, 1973 to January, 1995)

Available through NTIS:
National Technical Information Service (NTIS)
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Phone: (703) 487-4650
(FTS) 737-4600

The SWR No. is identified through the U. S. EPA Solid Waste Research Publications Department.

Covers
Design and Construction of Covers for Solid Waste Landfills, EPA 600/2-79/165
NTIS No. - PB 80-100381
SWR No. - 567

Evaluation of Municipal Solid Waste Landfill Cover Designs, EPA 600/2-86/110
NTIS No. - PB 88-171327
SWR No. - 927

The Use of Alternative Materials for Daily Cover at Municipal Solid Waste Landfills, EPA 600/R-93/172
NTIS No. - PB 93-227197
SWR No. - 1121

Liners
Use of Liner Materials for Land Disposal Facilities, SW 732
NTIS No. - N/A
SWR No. - 539

Preventing Landfill Leachate Contamination of Water, EPA 670/2-74/088

NTIS No. - PB 238145/AS
SWR No. - 434

Evaluation of Liner Materials Exposed to Leachate--Second Interim Report, EPA 600/2-76/255
NTIS No. - PB 2599336/8BE
SWR No. - 548

Liner Materials Exposed to MSW Leachate--Third Interim Report, EPA 600/2-82/097
NTIS No. - PB 83-147801
SWR No. - 769

Field Verification of Liners from Sanitary Landfills, EPA 600/2-83/046
NTIS No. - PB 83-217810
SWR No. - 771

Compatibility of Flexible Membrane Liners and MSW Leachates, EPA 600/2-91/040
NTIS No. - PB 91-231522
SWR No. - 1018

Proceedings of the Workshop on Geomembrane Seaming: Data Acquisition and Control, EPA 600/R-93/112
NTIS No. - PB 94-114667
SWR No. - 1117

Pollutant Generation
Estimating Leachate Production from Closed Hazardous Waste Landfills, EPA 600/2-86/057
NTIS No. - PB 96-207503
SWR No. - 895

Composition of Leachates from Actual Hazardous Waste Sites, EPA 600/2-87/043
NTIS No. - PB 87-198743
SWR No. - 915

Pollutant Control - Liners
Flexible Membrane Liners in Roof Tub Exposure Test
NTIS No. - Unknown
SWR No. - 1051

Long-Term Exposure to FMLs and an Asphaltic Membrane to Hazardous Waste in One-Sided Exposure Cells
NTIS No. - Unknown
SWR No. - 1050

Liner Materials Exposed to Hazardous and Toxic Sludges-- First Interim Report, EPA 600/2-77/081
NTIS No. - PB 271013/AS
SWR No. - 458

Liners for Sanitary Landfills and Chemical and Hazardous Waste Disposal Sites, EPA 600/9-78/005
NTIS No. - PB 293335/AS
SWR No. - 499

Flue Gas Cleaning Sludge Leachate/Liner Compatibility Investigation--Interim Report, EPA 600/2-79/136
NTIS No. - PB 80-100480
SWR No. - 558

A Method for Determining the Compatibility of Hazardous Wastes, EPA 600/2-80/076
NTIS No. - PB 80-221005
SWR No. - 593

Effect of Flue Gas Cleaning Sludges on Selected Liner Materials, EPA 600/2-81/098
NTIS No. - PB 81-213365
SWR No. - 681

Potential Clogging of Landfill Drainage Systems, EPA 600/2-83/109
NTIS No. - PB 84-110550
SWR No. - 789

Laboratory Studies of Soil Bedding Requirements for Flexible Membrane Liners, EPA 600/2-84/021
NTIS No. - PB 84-141498
SWR No. - 815

Electrical Resistivity Technique to Assess the Integrity of Geomembrane Liners, EPA 600/2-84/180
NTIS No. - PB 85-122414
SWR No. - 836

Field Studies of Liner Installation Methods at Landfill and Surface Impoundments, EPA 600-2-84/168
NTIS No. - PB 85-117067
SWR No. - 809

Liner Materials Exposed to Hazardous and Toxic Wastes, EPA 600/2-84/169
NTIS No. - PB 85-121333
SWR No. - 837

Test Methods for Determining the Chemical Waste Compatibility of Synthetic Liners, EPA 600/2-85/029
NTIS No. - PB 85-182970
SWR No. - 850

Assessment of Synthetic Membrane Successes and Failures at Waste Storage and Disposal Sites, EPA 600/2-85/100
NTIS No. - PB 85-245637
SWR No. - 858

Resistance of Flexible Membrane Liners to Chemicals and Wastes, EPA 600/2-86/058
NTIS No. - PB 86-184496
SWR No. - 880

Avoiding Failure of Leachate Collection and Cap Drainage Systems, EPA 600/2-86/058
NTIS No. - PB 86-208733
SWR No. - 893

Geotextiles for Drainage, Gas Venting and Erosion Control at Hazardous Waste Sites, EPA 600/2-86/085
NTIS No. - PB 87-129557
SWR No. - 882

Evaluation of Flexible Membrane Liner Seams after Chemical Exposure and Simulated Weathering, EPA 600/2-87/015
NTIS No. - PB 87-166526
SWR No. - 925

Assessment of Techniques for In Situ Repair of Flexible Membrane Liners: Final Report, EPA 600/2-87/038
NTIS No. - PB 87-191813
SWR No. - 931

Quantification of Leak Rates Through Holes in Landfill Liners, EPA 600/2-87/062
NTIS No. - PB 87-227466
SWR No. - 920

Development of Chemical Compatibility Criteria for Assessing Flexible Membrane Liners, EPA 600/2-87/067
NTIS No. - PB 87-227310
SWR No. - 951

Manual of Procedures and Criteria for Inspecting the Installation of Flexible Membrane Liners in Hazardous Waste Facilities, EPA 600/8-87/056
NTIS No. - PB 88-131313
SWR No. - 960

Geosynthetic Design Guidance for Hazardous Waste Landfill Cells and Surface Impoundments, EPA 600/2-87/097
NTIS No. - PB 88-131263
SWR No. - 958

Freeboard Determination and Management in Hazardous Waste Surface Impoundments, EPA 600/2-88/015
NTIS No. - PB 88-243787
SWR No. - 932

Factors in Assessing the Compatibility of FML's and Waste Liquids, EPA 600/2-88/017
NTIS No. - PB 88-173372
SWR No. - 972

The Electrical Leak Location Method for Geomembrane Liners, EPA 600/2-88/035
NTIS No. - PB 88-220496
SWR No. - 987

Loading Point Puncturability Analysis of Geosynthetic Liner Materials, EPA 600/2-88/040
NTIS No. - PB 88-235544
SWR No. - 985

Technical Considerations for DeMimimis Pollutant Transport Through Polymeric Liners, EPA 600/2-88/042
NTIS No. - PB 88-238332
SWR No. - 983

Consensus Report of the AD HOC Meeting on the Service Life in Landfill Environments of Flexible Membrane Liners and other Synthetic Polymeric Materials of Construction, EPA 600/X-88/252
NTIS No. - Unknown
SWR No. - 988

Stability of Lined Slopes at Landfills and Surface Impoundments, EPA 600/2-89/057
NTIS No. - PB 90-251877
SWR No. - 1023

Fundamental Approach to Service Life of Flexible Membrane Liners's (FMLs), EPA 600/2-90/041
NTIS No. - PB 90-263856
SWR No. - 1021

Service Life of Geosynthetics in Hazardous Waste Management Facilities, EPA 600/10-91/018
NTIS No. - PB 91-162826
SWR No. - N/A

Time-Domain Reflextometry and Acoustic-Emission Monitoring Techniques for Locating Liner Failures
NTIS No. - Unknown
SWR No. - 1040

Compilation of Information Alternative Barriers for Liner and Cover Systems, EPA 600/2-91/002
NTIS No. - PB 91-141846
SWR No. - 1019

Sorption and Transport of Gases in Glassy Polymers
NTIS No. - PB 91-145151
SWR No. - 1038

Landfill Leachate Clogging of Geotextile (and Soil) Filters, EPA 600/2-91/025
NTIS No. - PB 91-213660
SWR No. - 1013

LCDR Flow from Double-Lined Landfills and Surface Impoundments, EPA 600/R-93/005
NTIS No. - PB 93-179885
SWR No. - 1114

Report on Workshop on Geosynthetic Clay Liners, EPA 600/R-93-
NTIS No. - Unknown
SWR No. - 1118

Pollutant Control - Models and Expert Systems
Verification of the Hydrologic Evaluation of Landfill Performance (HELP) Model Using Field Data, EPA 600/2-87/050

NTIS No. - PB 87-227518
SWR No. - 993

Verification of the Lateral Drainage Component of the HELP Model Using Physical Models, EPA 600/2-87/049
NTIS No. - PB 87-227104
SWR No. - 934

Evaluation of Hydrologic Models in the Design of Stable Landfill Covers, EPA 600/2-88/048
NTIS No. - PB 88-243811
SWR No. - 979

Closure Evaluation System (CES): Includes Final Cover, Vegetative Cover and Leachate Collection Systems
NTIS No. - PB 93-502870 (Software - EPA/SW/DK-93/032)
SWR No. - 1125
NTIS No. - PB 93-144533 (User's Guide - EPA/SW/DK-93/032a)
SWR No. - 1125

Flexible Membrane Liner System, (FLEX), User Guide to Version 3.0
NTIS No. - PB 93-502631 (Software - EPA/SW/DK-93/029)
SWR No. - 1125
NTIS No. - PB 93-134872 (User's Guide - EPA/SW/DK-93/029a)
SWR No. - 1125

Geosynthetic Modeling System (GM), Version 1.1
NTIS No. - PB 93-502870 (Software - EPA/SW/DK-93/031)
SWR No. - 1125
NTIS No. - PB 93-144525 (User's Guide - EPA/SW/DK-93/031a)
SWR No. - 1125

Hydrologic Evaluation of Landfill Performance (HELP) Model -- Version 3.01
NTIS No. - Unknown (User's Guide - EPA/600/R-94/168a)
SWR No. - 1125
NTIS No. - Unknown (Engineering Documentation - EPA/600/R-94/168b)
SWR No. - 1125

Pollutant Control - Cover
Assessment of Technology for Construction and Installing Cover and Bottom Liner Systems for Hazardous Waste Facilities - Volume 1
NTIS No. - Unknown
SWR No. - 1042

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NTIS No. - Unknown
SWR No. - 1944

Evaluating Cover Systems for Solid and Hazardous Waste, W-867
NTIS No. - PB 87-154894
SWR No. - 689

Settlement and Cover Subsidence of Hazardous Waste Landfills, EPA 600/2-85/035
NTIS No. - PB-85-188829
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SWR No. - 997

Design, Construction, and Maintenance of Cover Systems for Hazardous Waste: An Engineer Guidance Document, EPA 600/2-87/039
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SWR No. - 929

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NTIS No. - PB 92-120435
SWR No. - N/A

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Assessment of Innovative Technologies to Detect Waste Impoundment Liner Facilities, EPA 600/2-84/041
NTIS No. - PB 84-157858
SWR No. - 800

Innovative Concepts for Detecting and Locating Leaks in Waste Impoundment Liner Systems: Acoustic Emission Monitoring and Time Domain Reflectometry, EPA 600/2-84/058
NTIS No. - PB 84-161819
SWR No. - 819

Covers for Uncontrolled Hazardous Waste Sites EPA 540/2-85/002
NTIS No. - PB 87-119483
SWR No. - 886

Technical Resource Documents for Landfills
Lining of Waste Impoundment and Disposal Facilities, SW-870
NTIS No. - PB 86-192796
SWR No. - 701

Evaluating Cover Systems for Solid and Hazardous Waste, SW-867
NTIS No. - PB 87-154894
SWR No. - 698

Closure of Hazardous Waste Surface Impoundments, SW-873
NTIS No. PB 87-155537
SWR No. - 704

Technical Guidance Document: Construction Quality Assurance for Hazardous Waste Land Disposal Facilities, EPA 530/SW-86/031
NTIS No. - PB 87-132825
SWR No. - 908

Geotextiles for Drainage, Gas Venting and Erosion Control at Hazardous Waste Sites, EPA 600/2-86/085
NTIS No. - PB 87-129557
SWR No. - 882

Lining of Waste Containment and Other Impoundment Facilities, EPA 600/2-88/952
NTIS No. - PB 89-129670
SWR No. - 1029

Technical Guidance Document: The Fabrication of Polyethylene FML Field Seams, EPA 530/SW-89/069
NTIS No. - PB 90-119595
SWR No. - 1005

Guidance Manual for Assuring Construction Quality for Flexible Membrane Liners
NTIS No. - Unknown
SWR No. - 1045

Technical Guidance Document: Inspection Techniques for the Fabrication of Geomembrane Field Seams, EPA 530/SW-91/051
NTIS No. - PB 92-109057
SWR No. - 1015

Technical Handbooks for Contaminated Soils
Lining of Waste Containment and Other Impoundment Facilities, EPA 600/2-88/052
NTIS No. - PB 89-129670
SWR No. - 1029

Technical Guidance Document: "Quality Assurance and Quality Control for Waste Containment Facilities," EPA 600/R-93/183
NTIS No. - 93-
SWR No. - 1120

Appendix "B"
Koerner / Geosynthetic Institute letter dated March 10, 2014

Appendix "C"
ASTM D7909-14 Standard Guide for Placement of Blind Actual Leaks during Electrical Leak Location Surveys of Geomembranes

Appendix "D"
ASTM D7240 - 06(2011) Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)

Appendix "E"
ASTM D7703 - 15 Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Lance Method

Appendix "F"
ASTM D7002 - 15 Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Puddle Method

Appendix "G"
"Assessment and Recommendations for Improving the Performance of Waste Containment Systems",
R. Bonaparte, D.E. Daniel, and R.M. Koerner, EPA/600/R-02/099,
http://www.epa.gov/nrmrl/pubs/600r02099.pdf

Appendix "H"
. "A Statistical Approach to Minimizing Landfill Leakage", SWANA, Washington D.C. Conference Proceedings. Beck, Abigail, 2012

Appendix "I"
"Geomembrane Liner Failure; modeling of its influence on contaminate transfer" Nosko,V. and Touze-Foltz, N, Proceedings of the Second European Geosynthetic Conference, Patron Editore, Bologna, Italy, (2000), pp-557-560.

Appendix "J"
"Available Technologies to Approach Zero Leaks", Beck A. Geosynthetics 2015 proceedings, Portland OR, (2015)

Appendix B

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March 10, 2014

Environmental Quality Board
P. O. Box 8477
Harrisburg, PA 17105-8477

RE: Proposed Amendments to 25 Pa-Code, Chapter 78, Subchapter C

Dear All,

We represent 72 firms and agencies dealing with the proper development and use of geosynthetic materials including "synthetic flexible liners" which are called "geomembranes" by many other organizations. Among our 18 agency members is the Pennsylvania Department of Environmental Protection with Steve Socash as our contact person… see our website at www.geosynthetic-institute.org for details. This communication has two major points which we ask you to seriously consider as you go forward with your regulations.

1. The original Subchapter C – Environmental Protection Performance Standards has a 1×10^{-7} cm/sec maximum permeability for the synthetic flexible liner being used. This is a ridiculously high value and represents a typical clay or silt soil. Geomembranes have permeabilities down to 1×10^{-13} cm/sec and should be referenced and regulated as such. The agency is confusing everyone (including the public) by having such a high value representing the liner material for all types of containment pits.
2. *The proposed January 15, 2014 regulation banning the use of lined pits is completely inappropriate.* A properly lined geomembrane pit manufactured with polymers such as high density polyethylene (HDPE) will outlast steel storage tanks by decades.[*] Attesting to this established fact is that <u>all</u> landfills and surface impoundments for nonhazardous and hazardous solid and liquid wastes are lined accordingly. Their performance has been documented over time and with the use of double lined systems allows for the development of an "action leakage rate" for ultimate security of adjacent land and waters.[**] Your proposed banning of geomembrane lined pits for flowback and

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[*] "Lifetime Prediction of Laboratory UV Exposed Geomembranes," by R. M. Koerner, G.R. Koerner, Y. G. Hsuan and W. K. Wong, GRI Report #42, January 3, 2013, 37 pgs.

[**] "Assessment and Recommendations for Improving the Performance of Waste Containment Systems," by R. Bonaparte, D. E. Daniel and R. M. Koerner, EPA/600/R-02/099, December 2002, 950 pgs.

production drilling waters flies in the face of the entire solid and liquid waste technology as practiced by the U.S. EPA and every state agency (including Pennsylvania) as well.

As a Pennsylvania resident my entire life and working with the PaDEP since its original founding, I ask you to re-consider your stance insofar as pit lining for flowback and production waters at drilling sites and operations. As you likely know the potential for contamination of these drilling fluids pales into insignificance in comparison to hazardous, and even nonhazardous, leachate from the solid and liquid waste industries.

Very truly yours,

Robert M. Koerner, Ph.D., P.E., NAE
Director Emeritus
Geosynthetic Institute

Attachment: resumé

APPENDIX C

Designation: D7909 – 14

Standard Guide for
Placement of Blind Actual Leaks during Electrical Leak Location Surveys of Geomembranes[1]

This standard is issued under the fixed designation D7909; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide is for placing blind actual leaks in geomembranes before performing an electrical leak location survey. The geomembranes can be bare (not covered) or can be covered with water or moist soil.

1.2 This guide is intended to serve as an additional quality control/quality assurance (QC/QA) measure to ensure that leaks through the geomembrane are detectable, site conditions are proper for leak location surveys, and a valid and complete leak location survey is performed. Because various leak location practitioners use a wide variety of equipment to perform these surveys and have a wide range of expertise, placement of blind actual leaks by the owner or owner's representative helps ensure that the leak location survey is being performed correctly and completely.

1.3 Placing blind actual leaks can also assist in determining whether or not the site conditions permit the flow of electric current through leaks, which is necessary for detecting leaks using electrical methods.

1.4 For clarification, this guide is in addition to the typical placement of the artificial or actual leaks placed as described in the relevant ASTM International standards for the various leak location methods.

1.5 Placing blind actual leaks should be done with the consent and knowledge of all involved parties and specifically the "owner" of the geomembrane. Geomembranes are typically purchased and installed by dedicated geosynthetic installers who "own" the geomembrane until the ownership gets transferred to the end user. A project meeting should be set up with the owner, the consultant, the geosynthetic installers, and the leak location contractor. The intention to use blind leaks should be clearly stated by the owner or consultants or both and the scope and number to be placed should be understood by all parties. The consultant should broadly identify to the lining contractor a location that can be easily repaired after the test. It is critical that all actual blind holes be included on the liner documentation and repair record drawing.

1.6 Leak location surveys can be used on geomembranes installed in basins, ponds, tanks, ore and waste pads, landfill cells, landfill caps, and other containment facilities. The procedures are applicable for geomembranes made of electrically insulating materials. (**Warning**—The electrical methods used for geomembrane leak location could use high voltages resulting in the potential for electrical shock or electrocution. This hazard might be increased because operations might be conducted in or near water. In particular, a high voltage could exist between the water or earth material and earth ground or any grounded conductor. These procedures are potentially very dangerous and can result in personal injury or death. The electrical methods used for geomembrane leak location should be attempted only by qualified and experienced personnel. Appropriate safety measures shall be taken to protect the leak location operators as well as other people at the site.)

1.7 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4439 Terminology for Geosynthetics

D6747 Guide for Selection of Techniques for Electrical Detection of Leaks in Geomembranes

D7002 Practice for Leak Location on Exposed Geomembranes Using the Water Puddle System

D7007 Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials

[1] This test method is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.10 on Geomembranes.

Current edition approved March 1, 2014. Published March 2014. DOI: 10.1520/D7909–14

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D7240 Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)

D7703 Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Lance System

3. Terminology

3.1 *Definitions:* For general definitions used in this guide, refer to Terminology D4439.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *artificial leak, n*—for the purposes of this guide, an artificial leak is an electrical simulation of a leak in a geomembrane during the leak detection sensitivity setup.

3.2.2 *blind actual leak, n*—for the purposes of this guide, a blind actual leak is a circular hole in the geomembrane intentionally placed by the owner or owner's representative to ensure that the site conditions are suitable for an electrical leak location survey and that a valid electric leak location survey is performed in a location unknown to the leak location practitioner.

3.2.2.1 *Discussion*—A blind actual leak is not a leak used to determine the leak detection sensitivity parameters.

3.2.3 *electrical leak location, n*—method that uses electrical current or electrical potential to detect and locate leaks in electrically isolating geomembranes.

3.2.4 *leak, n*—for the purposes of this guide, a leak is any unintended opening, perforation, breach, slit, tear, puncture, crack, or seam breach in electrically isolating geomembranes.

3.2.4.1 *Discussion*—Significant amounts of liquids or solids may or may not flow through a leak. Scratches, gouges, dents, or other aberrations that do not completely penetrate the geomembrane are not considered to be leaks.

3.2.5 *leak detection sensitivity, n*—smallest size leak that the leak location equipment and survey methodology are capable of detecting under a given set of conditions.

3.2.5.1 *Discussion*—The leak detection sensitivity specification is usually stated as a diameter of the smallest leak that can be reliably detected.

4. Significance and Use

4.1 Geomembranes are used as low-permeability barriers to control liquids from leaking from landfills, ponds, and other containments. The liquids may contain contaminants that, if released, can cause damage to the environment. Leaking liquids can also erode the subgrade. Leakage can result in product loss or otherwise prevent the installation from performing its intended containment purpose. For these reasons, it is desirable that the geomembrane have as little leakage as practical.

4.2 Geomembrane leaks can result even when the quality of the subgrade preparation, the quality of the material placed on the geomembrane, and the quality of the workmanship are not deficient.

4.3 Electrical leak location methods are an effective final quality assurance (QA) measure to locate previously undetected leaks in electrically insulating geomembranes. Practices for these implementations are contained in Guide D6747 and Practices D7002, D7007, D7240, and D7703.

4.4 It is important to realize that the detection of leaks depends not only on the capabilities of the leak location equipment, procedures, and experience of the leak location practitioner but also on local site conditions that are not under the control of the leak location practitioner. In particular, to detect a leak, there shall be an electrical conduction path through the leak and through the materials above and below the leak to allow sufficient electrical current through the leak for detection. For some site conditions, such as a leak not making contact with the subgrade, dry geotextile, or geocomposite above or below the leak; dry materials above or below the leak; degree of isolation between the materials above and below the geomembrane; and other factors, may preclude the detection of leaks. Therefore, the use of a properly placed blind actual leak is also a test of site preparations and conditions.

4.5 It is not necessarily proper to conclude that, if a blind actual leak is not detected, a leak location survey, using the proper relevant ASTM International standard, has no validity. Real leaks that have more favorable site conditions and larger leaks may still be detected.

4.6 The importance of blind actual leaks is to provide an additional measure to assess whether the site conditions are proper for a leak location survey and that the electric leak location survey is performed correctly and completely. The use of blind actual leaks provides: (*1*) a check that the equipment is operating properly, (2) a test for proper survey coverage, and (*3*) a check that all survey data (results) have been assessed to confirm a proper survey has been done. These all result in a high likelihood that significant-sized leaks are detected.

5. Procedural Guidance for Placement of Blind Actual Leaks

5.1 The fact that blind actual leak(s) will be installed in the geomembrane, and who will install the blind leak(s), who will survey the locations of the blind leak(s), and finally who will repair the blind actual leaks should be clearly described in the project specifications and understood by all affected parties so responsibilities and costs involved are fully understood by all affected parties. For the geomembrane leak location survey and use of blind actual leaks to be decisive, the project specifications should also specify the relevant ASTM International standard procedures to be used to perform the geomembrane leak location survey (see 2.1).

5.2 A realistic test of the leak detection sensitivity should be performed and documented as part of every leak location survey. The leak detection sensitivity of the leak location system via an actual or artificial leak is typically used according to the corresponding standard practices for the various leak location systems. The procedures for installing the actual leak holes for determining the leak detection sensitivity listed in the corresponding ASTM procedure can be used with the modifications described in 5.3 to place blind actual leaks.

5.3 The various electrical leak location practices all specify the use of actual leaks and procedures for making those actual leaks to determine the survey parameters and verify proper system operation. Leak detection is dependent upon the site conditions at each leak. Site conditions that affect leak detection sensitivity (particularly for surveys with earth materials on the geomembrane, to some degree with surveys on bare geomembranes) include:

5.3.1 Having adequate moisture throughout the overburden material and near subgrade,

5.3.2 Moisture in the leak,

5.3.3 The presence of dry insulating materials such as geotextile or geonet in contact with the leak,

5.3.4 Contact of the geomembrane with the overburden and subgrade,

5.3.5 Degree of isolation of the overburden from earth ground or the conducting material under the geomembrane, and

5.3.6 The composition of the material in contact with the liner (large stones may bridge a leak).

5.4 Because of these varying site conditions, detecting a leak of the same size as the actual leak used to determine the leak detection sensitivity as specified in the ASTM International standards (see 2.1) could be problematic. Better leak detection sensitivity will be obtained at some locations, and worse leak detection sensitivity will be obtained at other locations. The specific guidelines for installing blind actual leaks are:

5.4.1 The preferred blind actual leaks are to be constructed by drilling a hole with a minimum diameter of 1.0 mm for exposed geomembranes (1.4 mm for a blind actual leak for a water covered leak detection survey and 6.4 mm for a blind actual leak for an earthen covered leak detection survey) that is to be tested at the time of geomembrane installation. The blind actual leaks shall be installed the same day as the geomembrane installation, and as early as practical before the geomembrane leak location survey is performed so that the blind test leak will be exposed to the same conditions of rainfall, condensation, consolidation, and equilibrium as the rest of the geomembrane in the installation. If the blind actual leaks cannot be installed the same day as during geomembrane placement and installation, the diameters of the blind actual leak shall be increased to twice the above-mentioned diameters. Specifically, the blind actual leak diameter would result into using a diameter of 12.8 mm for geomembranes that are to be covered with earth materials, 2.8 mm for geomembranes that are to be covered with water, and 2.0 mm for bare geomembranes.

5.4.2 For a double geomembrane system or underlying geosynthetic clay liner (GCL), procedures shall ensure that the drill bit does not damage the secondary geomembrane or GCL. The hole shall be drilled, and the drill bit moved forward and backward in the hole so the geomembrane material is removed rather than just displaced. (**Warning**—Because of the shock or electrocution hazard that may be involved with high voltage, do not attempt to drill the blind actual leak with the excitation power supply on or connected.)

5.4.3 The blind actual leaks are to be installed by the owner or a representative of the owner without revealing the locations to the leak location practitioner or others.

5.4.4 The locations of the blind actual leaks shall be documented using appropriate land-surveying methods so the blind actual leaks can be located for future repair.

5.4.5 The blind actual leaks shall be put in representative locations and not on wrinkles, areas of bridging, in fusion seams, or other areas where the geomembrane is not in contact with the subgrade. They should not be placed within 5 m of the edge of the survey area.

5.4.6 The blind actual leaks shall be backfilled with a compaction representative of the rest of the installation. Ensure that any cavity made by the drill in the subgrade under the blind actual leak is filled with soil.

5.4.7 The number of placed blind actual leaks should be consistent with the size and complexity of the overall installation, as well as with the purposes for which the blind actual leaks are installed. The owner or owner's representative should consider the cost of installing, surveying, documenting, and repairing the blind actual leaks and the fact that a repair weld or patch of inferior integrity will replace an otherwise intact geomembrane.

5.5 In summary, for the leak location survey to detect the intentionally placed blind actual leaks successfully, the blind actual leaks should have conductivity through the openings; otherwise, they may not be detected. If the owner or owner's representative has their own independent leak location equipment, the blind actual leaks could be verified as they are being placed.

5.6 As a courtesy to the leak location survey practitioner, the owner or owner's representative should mention at the start of the survey that a blind actual leak has been placed in accordance with this guide.

5.7 This guide is not a replacement of the existing ASTM procedures governing leak location surveys. In summary, all the leak location equipment, personnel, and procedures should demonstrate the ability to detect the actual or artificial leak before commencing the leak location survey as described in the relevant ASTM International standards (see 2.1).

6. Guidance if Blind Actual Leak is Detected

6.1 If the blind actual leak is detected, it should be treated as any other detected leak and the relevant ASTM standard practice should be followed including documenting and reporting and, whenever specified, testing for additional leaks in the near vicinity.

7. Guidance if Blind Actual Leak is Not Detected

7.1 If the leak location survey practitioner does not detect a blind actual leak after surveying an area where the blind actual leak was placed, then the owner or owner's representative should mention that a blind actual leak was not detected. The leak location survey practitioner shall review the survey data to determine if the blind actual leak signal is indicated in the survey data. If a leak signal is discernible in the data, all of the data should be reviewed to determine if any other leak signals were missed. In addition, the leak location practitioner and the representative of the owner shall confirm that the survey successfully completed the leak detection sensitivity tests per the corresponding ASTM International procedure and that the survey was performed according to the ASTM International procedure.

7.2 If the blind actual leak was not detected (even after review of the survey data and confirming that the survey was performed properly per the relevant ASTM standard procedure) then the representative of the owner will show the leak location practitioner the position of the undetected blind actual leak and a leak location survey will be conducted to cover that area. If no leak signal is present in the repeat data, then the following potential conditions should be considered for each blind actual leak:

7.2.1 Subgrade restrictions (conductivity, moisture content, and so forth);

7.2.2 Proximity to survey boundary;

7.2.3 Geosynthetics underneath or above the geomembrane;

7.2.4 Uncovered material restrictions (waves, wrinkles, and so forth);

7.2.5 Cover material restrictions (conductivity, water saturation, and so forth);

7.2.6 Water requirement (depth necessary, quantity of water needed, bottom slope);

7.2.7 Proximity to protruding/penetrating accessories (pipes, steel bars, access platforms, ladders, concrete structure, and so forth). If so, the blind actual leak was not placed per the procedures of the relevant ASTM International standard;

7.2.8 The blind actual leak did not completely breach the thickness of the geomembrane; and

7.2.9 The blind actual leak was not in contact with the subgrade.

7.3 If it can be demonstrated that the blind actual leak was not detectable because of the considerations in 7.2.1 – 7.2.9 or other limitations and a detailed check with the leak location equipment shows that there is no electrical conductivity through the blind actual leak, then the blind actual leak (with its selected specific diameter) was, in fact, never detectable with that particular leak detection setup or site conditions. The cause of not being able to detect the blind leak should be investigated. If poor site conditions preclude the detection of the blind leak, then the site conditions should be modified in order to increase survey sensitivity. If modification of the site conditions enables detection of the blind leak, then the leak location survey should be repeated in any areas surveyed prior to modifying the site conditions. If it is determined that poor site conditions preclude the performance of a survey at the desired level of sensitivity and the site conditions cannot be altered, then the survey can nevertheless continue; however, with the knowledge that the desired level of sensitivity will be less than desired. In the extreme case where the site conditions preclude the performance of a survey on any size leak, such as a survey requested on non-conductive subgrade, then a leak location survey cannot be performed, and the failure to detect the blind actual leak does not indicate a shortcoming of the leak location survey. A report detailing the cause of the poor site conditions should be submitted in place of the leak location final report.

7.4 If the survey is ongoing for multiple days, it is recommended to review relevant ASTM International procedures to assure that the leak detection sensitivity test was implemented correctly. For example, the survey spacing could be optimized in accordance with relevant ASTM International standards (see 2.1). Alternatively, the size of the placed blind actual leak in the remainder of the survey can be increased to account for poor site conditions, with the exception where the site conditions preclude the performance of a survey altogether.

7.5 If it is deemed that the placed blind actual leak was not affected by the considerations in 7.2.1 – 7.2.9 or other limitations and the leak location practitioner cannot demonstrate functionality of the leak location equipment even though all components of the electrical leak path are proven to be sufficiently conductive for a survey and the survey is not affected by poor boundary conditions, then the blind actual leak was, in fact, never detectable with that particular leak detection equipment, and the failure to detect it indicates a shortcoming of the leak location practitioner. In that case, consideration should be given to repeating the leak location survey with different equipment or a different leak location practitioner, or both, until all actual blind leaks are successfully located. Responsibility for the cost of additional surveys will be in accordance with project contract requirements.

8. Keywords

8.1 artificial leak; blind actual leak; electrical leak location; geomembrane; leak detection; leak location

APPENDIX D

Designation: D 7240 – 06

Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)[1]

This standard is issued under the fixed designation D 7240; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard is a performance-based practice for using the spark test to electrically locate leaks in exposed geomembranes with an insulating layer that are in intimate contact with a conductive layer. For clarity, this document uses the term 'leak' to mean holes, punctures, tears, cuts, cracks and similar breaches over the partial or entire area of an installed geomembrane (as defined in 3.2.3).

1.2 This test method can be used on exposed geomembranes installed in basins, ponds, tanks, ore and waste pads, landfill cells, landfill caps, and other containment facilities. This standard is applicable for geomembranes in direct and intimate contact with a conductive surface or with a conductive layer integrally included.

1.3 **SAFETY WARNING:** The electrical methods used for geomembrane leak location use high voltage, low current power supplies, resulting in the potential for electrical shock. The electrical methods used for geomembrane leak location should be attempted by only qualified and experienced personnel. Appropriate safety measures must be taken to protect the leak location operators as well as other people at the site.

1.4 *This standard does not purport to address all of the safety and liability concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 4439 Terminology for Geosynthetics

D 6747 Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes

3. Terminology

3.1 Definition of terms applying to this test method appear in Terminology D 4439.

3.2 *Definitions:*

3.2.1 *electrical leak location, n*—a method which uses electrical current or electrical potential to detect and locate leaks.

3.2.2 *geomembrane, n*—an essentially impermeable membrane used with foundation, soil, rock, earth or any other geotechnical engineering related material as an integral part of a man made project, structure, or system.

3.2.3 *leak, n*—For the purposes of this document, a leak is any unintended opening, perforation, breach, slit, tear, puncture or crack. Significant amounts of liquids or solids may or may not flow through a leak. Scratches, gouges, dents, or other aberrations that do not completely penetrate the geomembrane are not considered to be leaks.

Leaks detected during surveys have been grouped into three categories:

- Holes – round shaped voids with downward or upward protruding rims
- Tears – linear or circular voids with irregular edge borders
- Linear cuts – linear voids with neat close edges

3.2.4 *intimate contact, n*—for the purposes of this document, intimate contact is when a conductive layer is in direct contact with the insulating geomembrane, and there are no gaps between the two layers to prohibit the flow of current.

3.2.5 *leak detection sensitivity, n*—The smallest size leak that the leak location equipment and survey methodology are capable of detecting under a given set of conditions. The leak detection sensitivity specification is usually stated as a diameter of the smallest leak that can be reliably detected.

3.2.6 *wand, n*—for the purposes of this document, any rod that has a conductive brush that is attached to a power source to initiate the spark test.

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[1] This practice is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.10 on Geomembranes.

Current edition approved Jan. 1, 2006. Published February 2006.

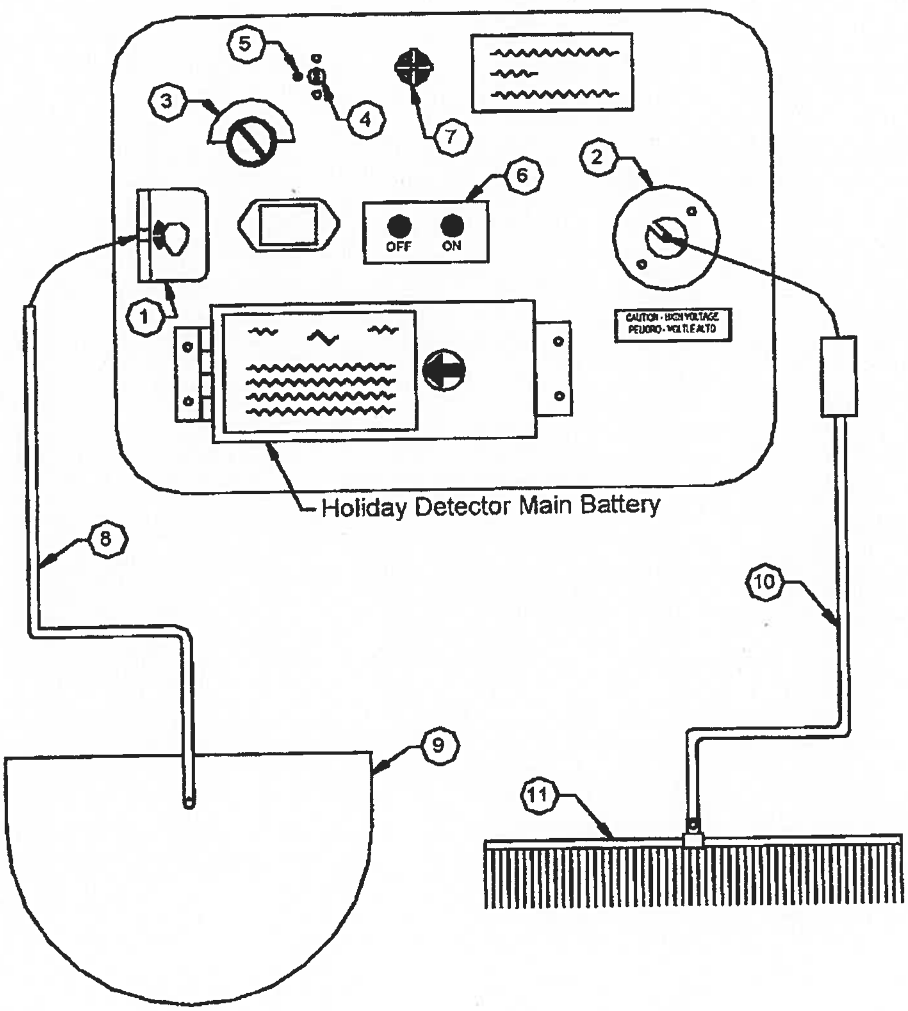
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

4. Summary of Practice

4.1 The principle of this electrical leak location method is to use a high voltage pulsed power supply to charge a capacitor formed by the underlying conductive layer, the non-conductive layer of the geomembrane and a coupling pad. The area is then swept with a test wand to locate points where the capacitor discharges through a leak. Once the system senses the discharge current, it is converted into an audible alarm.

4.2 *General Principles*

4.2.1 Fig. 1 shows a wiring diagram of the coupling pad, power supply and test wand for the electrical leak location method of a geomembrane with a lower conductive layer. Once all necessary connections are made, the pad is placed on the upper surface of the geomembrane. The nonconductive (insulating layer(s)) of the geomembrane act as a dielectric in a capacitor which stores electrical potential across the geomembrane.



Legend For Spark Tester Diagram

1. Ground Terminal
2. High Voltage Terminal
3. Sensitivity Dial
4. Voltage Dial (# x 1,000 = Wand Voltage)
5. Voltage Adjusting Screw (Remove plug first)
6. Main Power Switches
7. Alarm Buzzer
8. Ground Lead
9. Electrically Conductive Grounding Pad
10. High Voltage Lead
11. Wand

FIG. 1 Wiring Diagram of the Equipment Required for Spark Testing Geomembrane in Intimate Contact With a Conductive Surface.

4.2.2 A grid, test lanes or other acceptable system should be used to ensure that the entire area is tested with the test wand.

4.2.3 Either a hand held wand or a larger wand mounted to an all terrain vehicle may be used. Generally a hand held wand is a more efficient method unless the area is quite large and flat.

4.3 *Preparations and Measurement Considerations*

4.3.1 Testing must be performed on geomembranes that are clean and dry. For geomembrane covered by water or soils, other test procedures, such as described in Guide D 6747 will have to be used for testing the geomembrane.

4.3.2 Fusion and extrusion welds must be tested using state of the practice nondestructive methods such as air channel test and vacuum box test, respectively. If the test wand gets too close to the edge of the conductive geomembrane, the electrical charge can arc to the back side of the conductive geomembrane and may cause a false positive.

5. Significance and Use

5.1 Geomembranes are used as barriers to prevent liquids from leaking from landfills, ponds, and other containments. For this purpose, it is desirable that the geomembrane have as little leakage as practical.

5.2 The liquids may contain contaminants that if released can cause damage to the environment. Leaking liquids can erode the subgrade, causing further damage. Leakage can result in product loss or otherwise prevent the installation from performing its intended containment purpose.

5.3 Geomembranes are often assembled in the field, either by unrolling and welding panels of the geomembrane material together in the field, or unfolding smaller flexible geomembranes in the field.

5.4 In exposed geomembrane applications, geomembrane leaks can be caused by poor quality of the subgrade, accidents, poor workmanship, and carelessness.

5.5 Electrical leak location methods are an effective final quality assurance measure to locate previously undetected leaks.

6. Procedure

6.1 Before beginning a leak survey, the equipment must be checked to ensure it is in working order. The power source should have a range of voltage from 15,000 to 35,000 volts. A wider voltage range is acceptable but the maximum is typically 35,000 volts. The test wand may be up to 6 feet wide with a brass brush. The coupling pad should be connected as shown in Fig. 1.

6.2 Once the equipment has been checked and wired properly, a trial test must be performed. A puncture (deliberate defect) should be introduced in a test piece of geomembrane. The deliberate defect should be approximately 1 mm in diameter. The test piece of geomembrane must be of sufficient size to enable movement of the brush at normal testing speed over the deliberate defect without touching the edges of the test piece or the coupling pad.

6.3 Place the test piece on a large scrap of geomembrane or on the installed geomembrane with the conductive side down. The deliberate defect and the coupling pad should both be on the large scrap piece of geomembrane.

6.3.1 Turn on the test unit and adjust the voltage and sensitivity to maximum settings.

6.3.2 Sweep the test piece with the wand ensuring that the test wand remains in contact with the geomembrane surface. It is important this be done at normal speeds.

6.3.3 Ensure the audible alarm sounds when the brush passes over the deliberate defect. If the alarm does not sound, recheck the connections and retest. If the alarm sounds prior to passing over the damage, turn the sensitivity down and retest the area. The minimum voltage required is site specific and will vary with atmospheric and other site conditions.

6.3.4 At a minimum, the equipment should be checked before testing begins and after any shut down of an hour or more. In the event a test reveals the equipment is not working properly, the entire area spark tested since the last passing check of the equipment will have to be retested to assure it was spark tested with working equipment.

6.4 Field testing may be performed by marking a predetermined grid, using a two person team or another acceptable method.

6.5 The leak location survey shall be conducted using procedures whereby the test wand contacts every point on the surface of the geomembrane being surveyed for leaks – neglecting the edge effects.

NOTE 1—Welded seams cannot be tested using this method. They must be tested by test procedures appropriate for such items – this standard practice applies only to the sections of geomembrane in between the welded edges.

NOTE 2—Actual survey speed must be no greater than survey speed used during trial test.

7. Reporting

7.1 The leak location survey report shall contain the following information

- Description of the survey site
- Description of test apparatus
- Climatic conditions
- Thickness of geomembrane
- Survey methodology
- Results of system functionality and calibration test
- Location, type and size of leaks
- Repair technique of detected leaks
- Map of the surveyed areas

8. Keywords

8.1 geomembrane; leak detection; leak location; electrical leak location method; construction quality assurance

APPENDIX E

Designation: D7703 – 11

Standard Practice for Electrical Leak Location on Exposed Geomembranes Using the Water Lance System[1]

This standard is issued under the fixed designation D7703; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard is a performance-based practice using the water lance system, a electrical method for detecting leaks in exposed geomembranes. For clarity, this document uses the term "leak" to mean holes, punctures, tears, knife cuts, seam defects, cracks and similar breaches in an installed geomembrane.

1.2 This standard can be used for geomembranes installed in basins, ponds, tanks, ore and waste pads, landfill cells, landfill caps, canals, and other containment facilities. It is applicable for geomembranes made of materials such as polyethylene, polypropylene, polyvinyl chloride, chlorosulfonated polyethylene, bituminous geomembrane, and any other electricallyinsulating materials. This standard may not be applicable for locating geomembrane leaks where the proper preparations have not been made during the construction of the facility.

1.3 **Warning—The electrical methods used for geomembrane leak location could use high voltages, resulting in the potential for electrical shock or electrocution. This hazard might be increased because operations might be conducted in or near water. In particular, a high voltage could exist between the water or earth material and earth ground, or any grounded conductor. These procedures are potentially VERY DANGEROUS, and can result in personal injury or death. The electrical methods used for geomembrane leak location should be attempted only by qualified and experienced personnel. Appropriate safety measures must be taken to protect the leak location operators as well as other people at the site.**

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4439 Terminology for Geosynthetics

D6747 Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes

D7007 Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials

3. Terminology

3.1 For general definitions used in this document, refer to D4439.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *artificial leak, n*—an electrical simulation of a leak in a geomembrane.

3.2.2 *current, n*—the flow of electricity or the flow of electric charge.

3.2.3 *electrode, n*—the conductive plate that is placed in earth or in the material under the geomembrane or a conductive element typically placed inside the water reservoir.

3.2.4 *electrical leak location, n*—a method which uses electrical current or electrical potential to detect and locate leaks.

3.2.5 *leak, n*—for the purposes of this document, a leak is any unintended opening, perforation, breach, slit, tear, puncture, crack, or seam breach. Significant amounts of liquids or solids may or may not flow through a leak. Scratches, gouges, dents, or other aberrations that do not completely penetrate the geomembrane are not considered to be leaks. Leaks detected during surveys have been grouped into five categories:

holes—round shaped voids with downward or upward protruding rims.

tears—linear or areal voids with irregular edge borders.

linear cuts—linear voids with neat close edges.

[1] This practice is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.10 on Geomembranes.

Current edition approved June 1, 2011. Published July 2011. DOI: 10.1520/D7703-11.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

seam defects—area of partial or total separation between sheets.

burned through zones—voids created by melting polymer during welding.

3.2.6 *leak detection sensitivity, n*—the smallest leak that the leak location equipment and survey methodology are capable of detecting under a given set of conditions. The leak detection sensitivity specification is usually stated as a diameter of the smallest leak that can be reliably detected.

3.2.7 *water stream, n*—for the purposes of this document, a continuous stream of water between the water lance and the geomembrane that creates a conduit for current to flow through any leaks.

3.2.8 *water lance, n*—for the purposes of this document, a probe (lance) incorporating two electrodes that directs a solid stream of water through a single nozzle mounted at the end.

4. Summary of Practice

4.1 *The Principle of the Electrical Leak Location Method Using the Water Lance System*:

4.1.1 The principle of the electrical leak location method is to place a voltage across a geomembrane and then locate areas where electrical current flows through leaks. ASTM Standard D6747 is a guide for the selection of the various implementations of the method.

4.1.2 Fig. 1 shows a diagram of the electrical leak location method of the water lance system for exposed geomembranes. One output of an electrical excitation power supply is connected to an electrode placed in the water reservoir; a pump sends this charged water to the water lance (Fig. 2) that jets the water in a solid stream on top of the geomembrane. The other output of the power supply is connected to an electrode placed in electrically conductive material under the geomembrane.

4.2 *Leak Location Surveys of Exposed Geomembrane Using the Water Lance System*:

4.2.1 The water lance detection system usually consists of a single nozzle mounted at the end of a probe (lance) (Fig. 2) that directs a solid stream of water onto a geomembrane, and an electronic detector assembly as shown in Fig. 3. A pressurized water source, usually from a small reservoir on top of the liner, or from a tank truck isolated from ground parked at higher elevation, is connected to the water lance using a plastic or rubber hose.

4.2.2 Direct current power supplies (often a 12 or 24 volt battery) have been used for leak location surveys.

4.2.3 For leak location surveys of exposed geomembrane, the solid water stream (not a spray) is moved systematically over the geomembrane area to locate the points where the electrical current flow increases as the charged water from the water lance contacts the oppositely charged conductive media under the geomembrane through a hole.

4.2.4 The voltage drop signal between the two electrodes in the water column in the water lance is typically connected to an electronic detector assembly that converts the electrical signal to an audible signal that increases in pitch and amplitude as the leak signal increases (Fig. 3).

4.2.5 When a leak signal is detected, the location of the leak is then marked or located relative to fixed points.

4.2.6 The leak detection sensitivity can be very good for this technique. Leaks smaller than 1 mm in diameter are routinely found, including leaks through seams in the geomembrane.

4.3 *Preparations and Measurement Considerations*:

4.3.1 Proper field preparations and other measures must be implemented to assure an electrical connection to the conductive material directly below the geomembrane is in place.

4.3.2 There must be a conductive material directly below the geomembrane being tested. Typically a properly-prepared subgrade will have sufficient conductivity. Under proper conditions and preparations, geosynthetic clay liners (GCLs) can be adequate as conductive material. There are some conductive geotextiles with successful field experience which can be installed beneath the geomembrane to facilitate electrical leak survey (that is, on dry subgrades, or as part of a planar drainage geocomposite).

4.3.3 Measures should be taken to perform the leak location survey when geomembrane wrinkles are minimized.

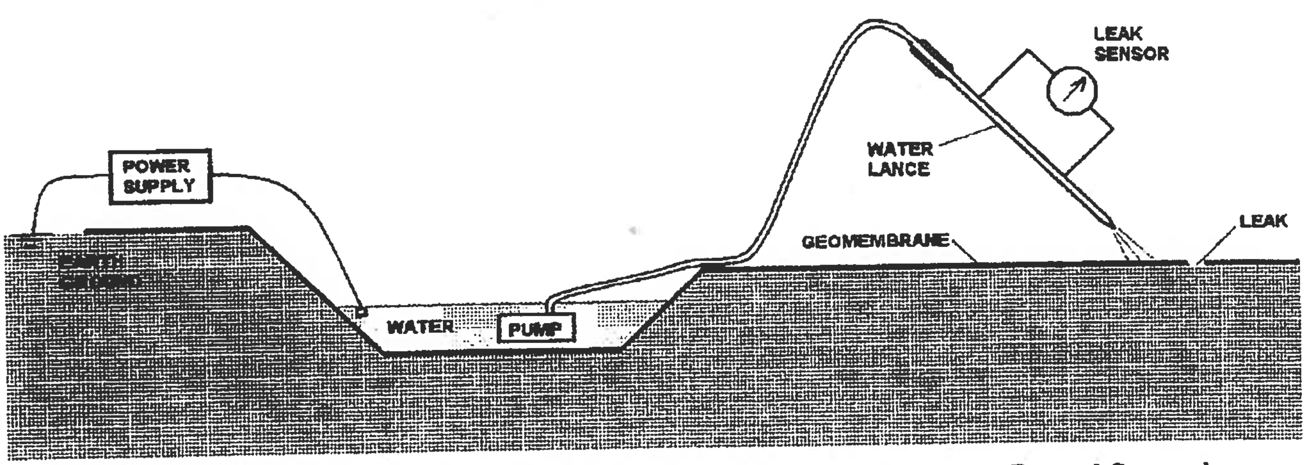


FIG. 1 Diagram of the Electrical Leak Location Method for Surveys with Water Lance on Exposed Geomembrane

FIG. 1 Diagram of the Electrical Leak Location Method for Surveys with Water Lance on Exposed Geomembrane

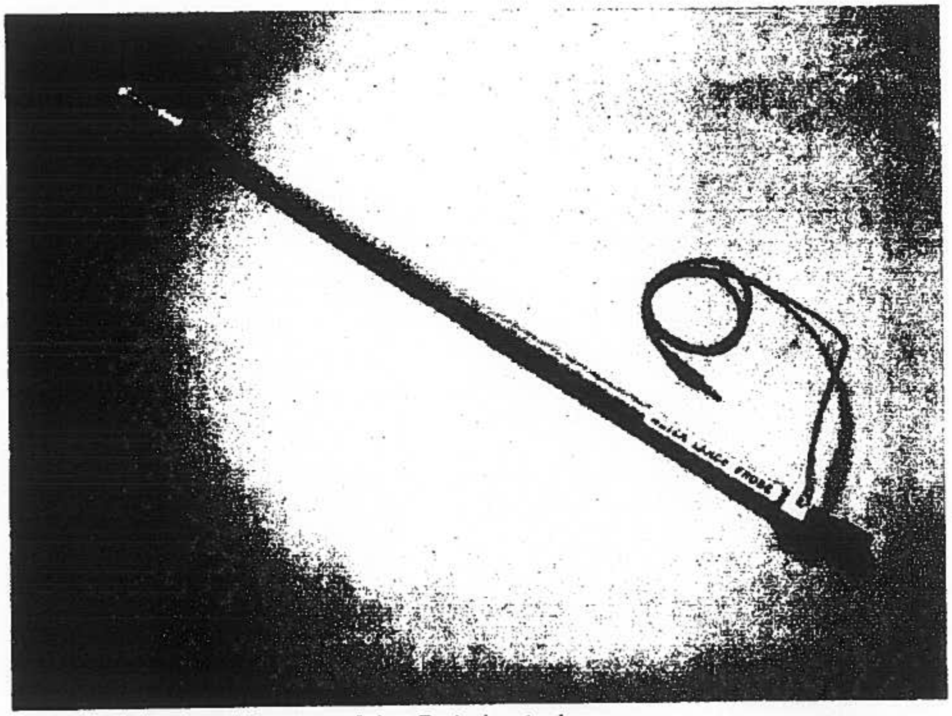


FIG. 2 Typical water lance

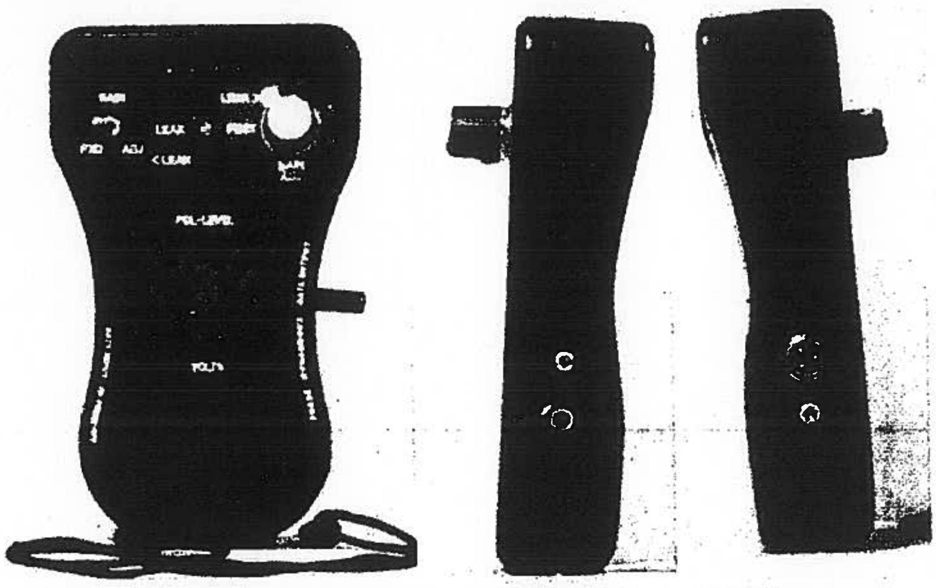


FIG. 3 Photographs of Water Lance Electronic Detector Assembly

NOTE 1—The leak location survey could be conducted at night or early morning when wrinkles are minimized. Sometimes wrinkles can be flattened by personnel walking or standing on them as the survey progresses. Condensation may provide a conductive layer under the geomembrane.

4.3.4 Conversely, surveys should not be made in areas with bridging geomembrane. The survey of areas with minor bridging might be accomplished when the geomembrane is warmer.

4.3.5 For lining systems comprised of two geomembranes with only a geonet or geotextile/geonet/geotextile composite (geocomposite) between them, to make the method feasible a conductive layer such as a conductive geotextile must be installed under the geomembrane or integrated into the geocomposite.

4.3.6 For best results, conductive paths such as metal pipe penetrations, pump grounds, and batten strips on concrete should be isolated or insulated from the water lance on the geomembrane. These conductive paths conduct electricity and mask nearby leaks from detection.

4.3.7 Depending on specific construction practices and site conditions, other preparations and support may still be needed to successfully perform the leak location survey.

4.3.8 The system characteristics are presented in Table 1.

5. Significance and Use

5.1 Geomembranes are used as barriers to prevent liquids from leaking from landfills, ponds, and other containments. For this purpose, it is desirable that the geomembrane have as little leakage as practical.

5.2 The liquids may contain contaminants that if released can cause damage to the environment. Leaking liquids can erode the subgrade, causing further damage. Leakage can result in product loss or otherwise prevent the installation from performing its intended containment purpose.

5.3 Geomembranes are often assembled in the field, either by unrolling and welding panels of the geomembrane material together in the field, or unfolding flexible geomembranes in the field.

5.4 Geomembrane leaks can be caused by poor quality of the subgrade, poor quality of the material placed on the geomembrane, accidents, poor workmanship, and carelessness. D7007 describes the electrical methods for locating leaks in Geomembranes Covered with Water or Earth Materials.

5.5 Electrical leak location methods are an effective and proven quality assurance measure to locate previously undetected leaks and check the integrity of a liner.

6. Procedure

6.1 A realistic test of the leak detection sensitivity shall be performed and documented as part of the leak location survey. An actual or artificial leak can be used. The leak location equipment and procedures should demonstrate the ability to detect the artificial or actual leak when the water stream is passed over the leak in the geomembrane.

6.2 *Artificial Leak*—An artificial leak may consist of the cut end of an insulated solid core wire, or an exposed metal disc mounted on a plastic plate and connected to a wire (Fig. 4). The assembly is placed on the surface of the liner. The wire is connected to an electrode in the subgrade such that current will flow through the subgrade for a distance equivalent to the distance between the center of the liner and the negative (ground) applied potential electrode.

6.3 *Actual Leak*—If an actual leak is used, which is technically preferred, it shall be constructed by drilling a 1 mm diameter hole in the installed geomembrane that is to be tested. For double geomembranes, measures must be taken to ensure that the secondary geomembrane is not damaged. The hole must be drilled at least 600 mm away from the edge of the geomembrane. The distance between the hole and the electrode in contact with the conductive media under the geomembrane should be greater than the distance between the center of the liner and the electrode in contact with the conductive media under the geomembrane. The hole should be drilled, and the drill bit reciprocated in the hole so the geomembrane material is removed rather than displaced.

6.4 The excitation power supply and the water supply shall be turned on, and the water stream shall be moved over the artificial or actual leak at a speed equal to the desired

TABLE 1 Characteristics of the Water Lance Leak Detection Technique

geomembranes	Bituminous, CSPE, CPE, EIA, fPP, HDPE, LLDPE, LDPE, PVC, VLDPE,	applicable	
	EPDM, GCL		not applicable
	exposed	applicable	
	covered		not applicable
GCL	GCL		not applicable
characteristics	set up time and leak detection sensitivity test	1 to 3 h	
	measurement time	Instantaneous	
	average survey speed (horizontal surface)	900 m^2 per hour per operator	
seams	all types: welded, tape, adhesive, glued and other	applicability is project specific	
	Seams of patches		not usually applicable
junctions	at synthetic pipes and accessories	applicability is project specific	
	at permanent structure	applicability is project specific	
survey	during construction phase (installation of GM)	applicable	
	after installation (exposed)	applicable	
	after soil covering		not applicable
	presence of large wrinkles and waves		not applicable
	slopes		
	during the service life (if exposed)	applicable	
	electrical isolated conductive structures	applicable	
	presence of bridging		not applicable
climate	sunny, temperate, warm	applicable	
	rainy weather, freezing weather		not applicable
leak detected	size of 1 mm and larger	applicable	
	discrimination between multiple leaks	applicable	

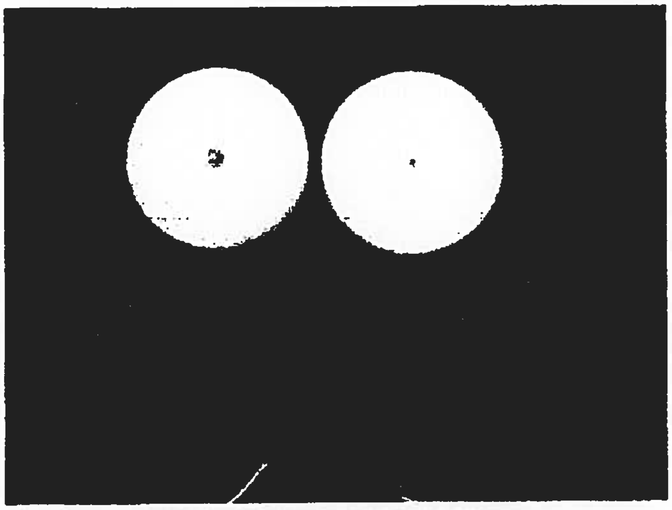


FIG. 4 Photographs of Artificial Leaks

production survey speed. Ideally testing shall progress from areas of lower elevation to areas of higher elevation

6.5 The resulting signal as the stream passes over the hole shall be distinctly and consistently greater than the background level. The applied potential across the liner and the signal meter controls shall be adjusted to achieve such a signal.

6.6 The leak location survey shall be conducted using the same water distribution speed as that used for the leak detection sensitivity test. The survey shall not be performed any farther from the electrode in contact with the conductive media under the geomembrane than the distance between the leak detection sensitivity test and the electrode in contact with the conductive media under the geomembrane.

6.7 Periodic testing of the integrity of the electrical circuit is recommended. It is recommended to check the integrity of the electrical circuit every 15 to 20 minutes by contacting the conductive media under the geomembrane with the water stream or by using an extra electrical cable well-connected to the conductive media under the geomembrane. At a minimum, this check shall be conducted at the beginning and end of each day of survey. If the equipment fails to pass the periodic test, then the area surveyed with that set of equipment in the period since the previous successful periodic test shall be repeated.

7. Report

7.1 The leak location survey report shall contain the following information:

7.1.1 Description of the survey site,

7.1.2 Climatic conditions,

7.1.3 Climatic conditions,

7.1.4 Liner system layering,

7.1.5 Description of the leak location method,

7.1.6 Survey methodology,

7.1.7 Identification of equipment and operators,

7.1.8 Results of artificial or actual leak sensitivity test,

7.1.9 Results of periodic sensitivity test,

7.1.10 Specific conditions of survey,

7.1.11 Location, type and size of detected leaks, and

7.1.12 Map of the surveyed areas showing the approximate locations of the leaks.

8. Keywords

8.1 electrical leak location method; geomembrane; leak detection

APPENDIX F

Designation: D 7002 – 03

Standard Practice for Leak Location on Exposed Geomembranes Using the Water Puddle System[1]

This standard is issued under the fixed designation D 7002; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard is a performance-based practice for electrical methods for detecting leaks in exposed geomembranes. For clarity, this document uses the term "leak" to mean holes, punctures, tears, knife cuts, seam defects, cracks and similar breaches in an installed geomembrane (as defined in 3.1.5).

1.2 This standard can be used for geomembranes installed in basins, ponds, tanks, ore and waste pads, landfill cells, landfill caps, canals and other containment facilities. It is applicable for geomembranes made of materials such as polyethylene, polypropylene, polyvinyl chloride, chlorosulfonated polyethylene, bituminous geomembrane, and any other electrically-insulating materials.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 4439 Terminology for Geosynthetics

D 6747 Guide for Selection of Techniques for Electrical Detection of Potential Leak Paths in Geomembranes

3. Terminology

3.1 *Definitions:*

3.1.1 *artificial leak, n*—an electrical simulation of a leak in a geomembrane.

3.1.2 *electrodes, n*—the conductive plate that is placed in earth ground or in the material under the geomembrane or a conductive structure, such as a copper manifold, that is placed in the water puddle on the geomembrane.

3.1.3 *electrical leak location, n*—a method which uses electrical current or electrical potential to detect and locate leaks.

3.1.4 *geomembrane, n*—an essentially impermeable membrane used with foundation, soil, rock, earth or any other geotechnical engineering related material as an integral part of a man made project, structure, or system.

3.1.5 *leak, n*—for the purposes of this document, a leak is any unintended opening, perforation, breach, slit, tear, puncture, crack, or seam breach. Significant amounts of liquids or solids may or may not flow through a leak. Scratches, gouges, dents, or other aberrations that do not completely penetrate the geomembrane are not considered to be leaks. Leaks detected during surveys have been grouped into five categories:

3.1.5.1 *holes*—round shaped voids with downward or upward protruding rims.

3.1.5.2 *tears*—linear or areal voids with irregular edge borders.

3.1.5.3 *linear cuts*—linear voids with neat close edges.

3.1.5.4 *seam defects*—area of partial or total separation between sheets.

3.1.5.5 *burned through zones*—voids created by melting polymer during welding.

3.1.6 *leak detection sensitivity, n*—the smallest leak that the leak location equipment and survey methodology are capable of detecting under a given set of conditions. The leak detection sensitivity specification is usually stated as a diameter of the smallest leak that can be reliably detected.

3.1.7 *current, n*—the flow of electricity or the flow of electric charge.

3.1.8 *water puddle, n*—for the purposes of this document, a water puddle is a small pool of water being contained and pushed by a squeegee installed on the leak location system.

3.1.9 *squeegee, n*—for the purposes of this document, a squeegee is a device used to contain and push water on top of an exposed geomembrane. It may consist of a handle and a transverse piece at one end set with a strip of leather or rubber.

3.1.10 *metalized geotextile, n*—a geotextile incorporating metallic strips that can conduct electrical current.

4. Summary of Practice

4.1 *The Principle of the Electrical Leak Location Method Using the Water Puddle System:*

[1] This practice is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.10 on Geomembranes.
Current edition approved Dec. 1, 2003. Published December 2003.

4.1.1 The principle of the electrical leak location method is to place a voltage across a geomembrane and then locate areas where electrical current flows through discontinuities in the geomembrane and at seams.

4.1.2 Fig. 1 show a diagram of the electrical leak location method of the water puddle system for exposed geomembranes. One output of an electrical excitation power supply is connected to an electrode placed in a water puddle created on top of the geomembrane. The other output of the power supply is connected to an electrode placed in electrically conductive material under the geomembrane.

4.1.3 Measurements are made using an electrical current measurement system, the magnitude of the current being related to the size of the leak. An electronic assembly is usually used to produce an audio tone whose frequency is proportional to the current flow.

4.2 *Leak Location Surveys of Exposed Geomembrane Using the Water Puddle System*:

4.2.1 The water puddle detection system usually consists of a horizontal water spray manifold with multiple nozzles that spray water onto a geomembrane, a squeegee device to push the resultant puddle of water, and a handle assembly as shown in Fig. 2. A pressurized water source, usually from a tank truck parked at higher elevation, is connected to the spray manifold using a plastic or rubber hose. Figs. 3 and 4 show one example of such an apparatus.

4.2.2 Direct current power supplies (usually a 12 or 24 volt battery) have been used for leak location surveys. An alternating current (output requirement of 12 to 30 volt AC) could be used.

4.2.3 For leak location surveys of exposed geomembrane, the water puddle created is pushed systematically over the geomembrane area to locate the points where the electrical current flow increases.

4.2.4 The signal from the probe is typically connected to an electronic detector assembly that converts the electrical signal to a detector and an audible signal that increases in pitch and amplitude as the leak signal increases.

4.2.5 When a leak signal is detected, the location of the leak is then marked or measured relative to fixed points.

4.2.6 The leak detection sensitivity can be very good for this technique. Leaks smaller than 1 mm in diameter are routinely found, including leaks through seams in the geomembrane.

4.2.7 The survey rate depends primarily on the manifold and squeegee width and the presence of wrinkles and waves in the geomembrane.

4.3 *Preparations and Measurement Considerations*:

4.3.1 There must be a conductive material below the geomembrane being tested. Leak location survey of geomembrane have been conducted with a conductivity of a subgrade equivalent to sand with moisture greater than 0.7 % (by weight). A properly-prepared subgrade typically will have sufficiently conductivity. Under proper conditions and preparations, geosynthetic clay liners (CGLs) can be also adequate.

4.3.2 Measures should be taken to perform the leak location survey when geomembrane wrinkles are minimized. For flexible geomembranes, sometimes the wrinkles can be flattened by personnel walking on them immediately in front of the survey. For surveys with wrinkles in rigid geomembranes, the leak location survey should be conducted at night or early morning.

4.3.3 For lining systems comprised of two geomembranes with only a geonet or geocomposite between them, the method is not applicable. For lining systems comprised of two geomembranes separated by a metalized geotextile, the method is applicable.

4.3.4 For best results, conductive paths such as metal pipe penetrations, pump grounds, and batten strips on concrete should be isolated or insulated from the water puddle on the geomembrane. These conductive paths conduct electricity and mask nearby leaks from detection.

4.3.5 The system specifications are presented in Table 1.

5. Significance and Use

5.1 Geomembranes are used as barriers to prevent liquids from leaking from landfills, ponds, and other containments. For this purpose, it is desirable that the geomembrane have as little leakage as practical.

5.2 The liquids may contain contaminants that if released can cause damage to the environment. Leaking liquids can erode the subgrade, causing further damage. Leakage can result in product loss or otherwise prevent the installation from performing its intended containment purpose.

5.3 Geomembranes are often assembled in the field, either by unrolling and welding panels of the geomembrane material together in the field, or unfolding flexible geomembranes in the field.

5.4 Geomembrane leaks can be caused by poor quality of the subgrade, poor quality of the material placed on the geomembrane, accidents, poor workmanship, and carelessness.

5.5 Electrical leak location methods are an effective quality assurance measure to locate previously undetected or missed leaks and check the integrity of a liner.

6. Practices for Surveys with Water Puddle System

6.1 A realistic test of the leak detection sensitivity should be performed and documented as part of the leak location survey. An actual or artificial leak can be used. The leak location equipment and procedures should be demonstrated to be able to detect the artificial or actual leak when water puddle is passed over the leak on the geomembrane.

6.2 *Artificial Leak*—If an artificial leak is used, it shall be constructed by drilling a 1 mm diameter hole in approximately the center of a piece of geomembrane. The piece of geomembrane should have a width of at least twice the width of the squeegee, and a length of at least four times the width of the squeegee. The hole should be drilled, and the drill bit reciprocated in the hole so the geomembrane material is removed rather than displaced. The artificial leak shall be placed on a subgrade that is prepared to be the same as the subgrade under the actual geomembrane. When surveying leak detection on existing containment facilities, a geomembrane sample equivalent to the liner installed should be used.

6.3 *Actual Leak*—If an actual leak is used, it shall be constructed by drilling a 1 mm diameter hole in the installed geomembrane that is to be tested. For double geomembranes,

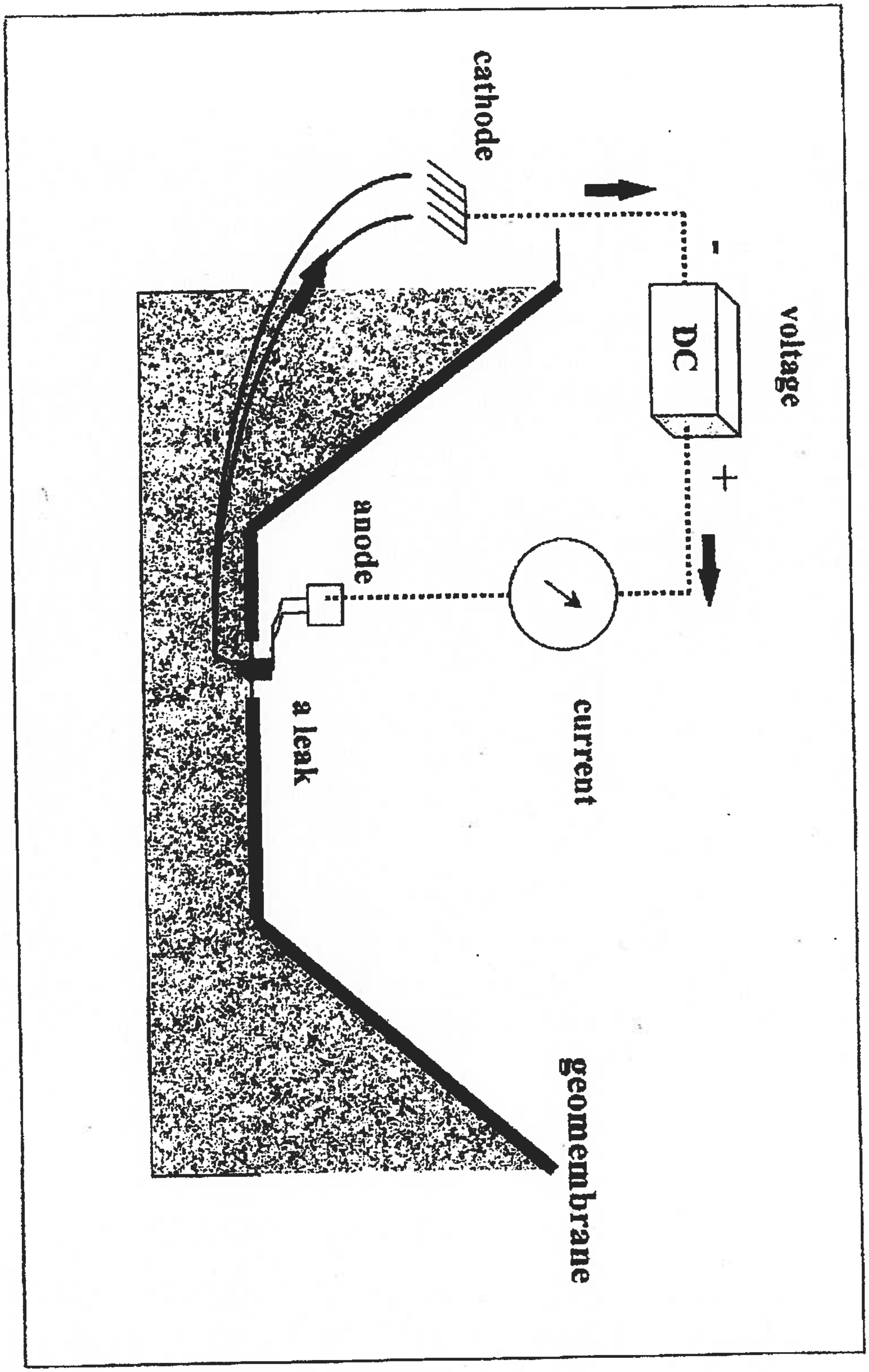


FIG. 1 Diagram of the Electrical Leak Location Method for Surveys with Water Puddle on Exposed Geomembrane

measures must be taken to ensure that the secondary geomembrane is not damaged. The hole must be drilled at least the

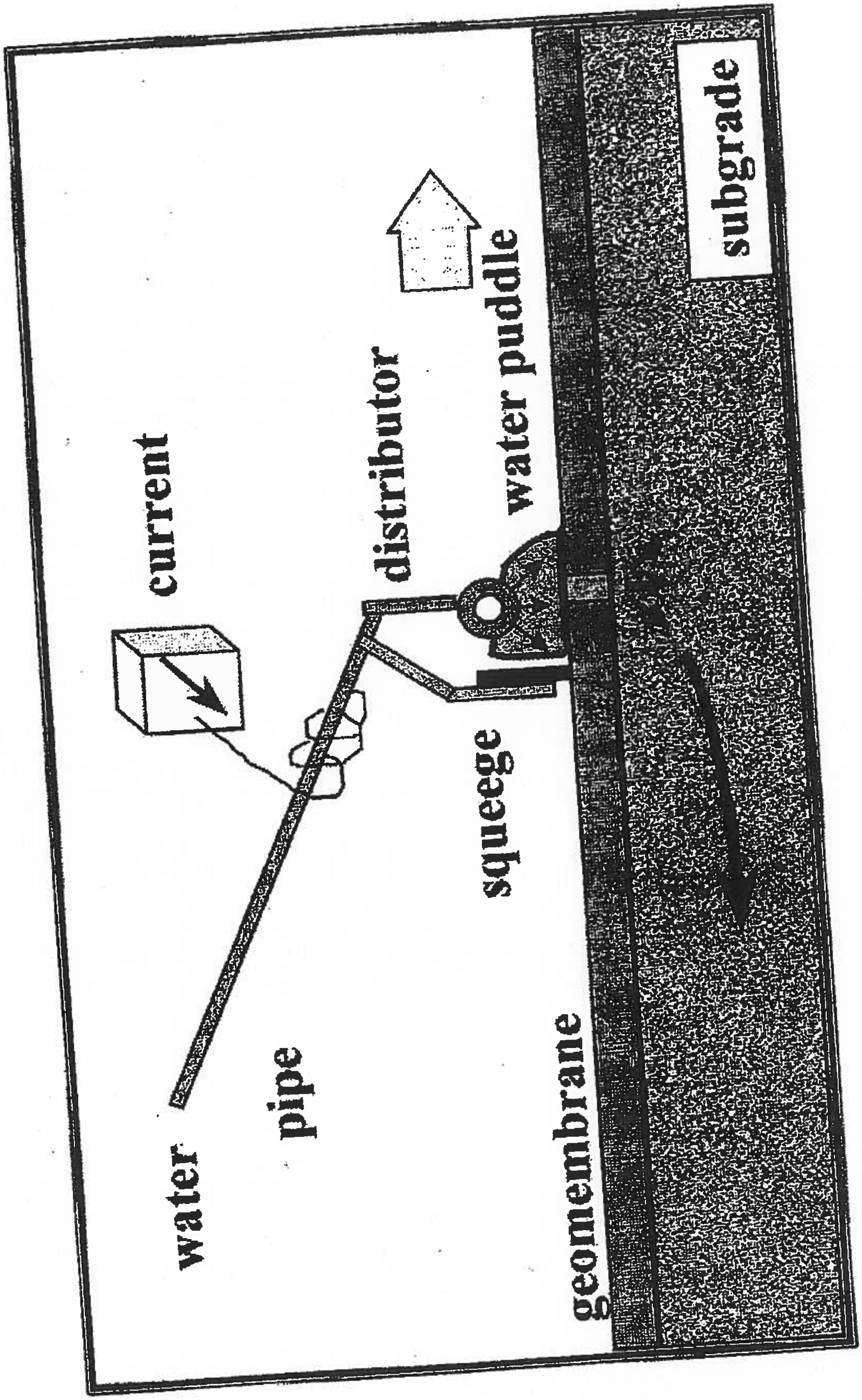


FIG. 2 Diagram of Electrical Leak Water Puddle System

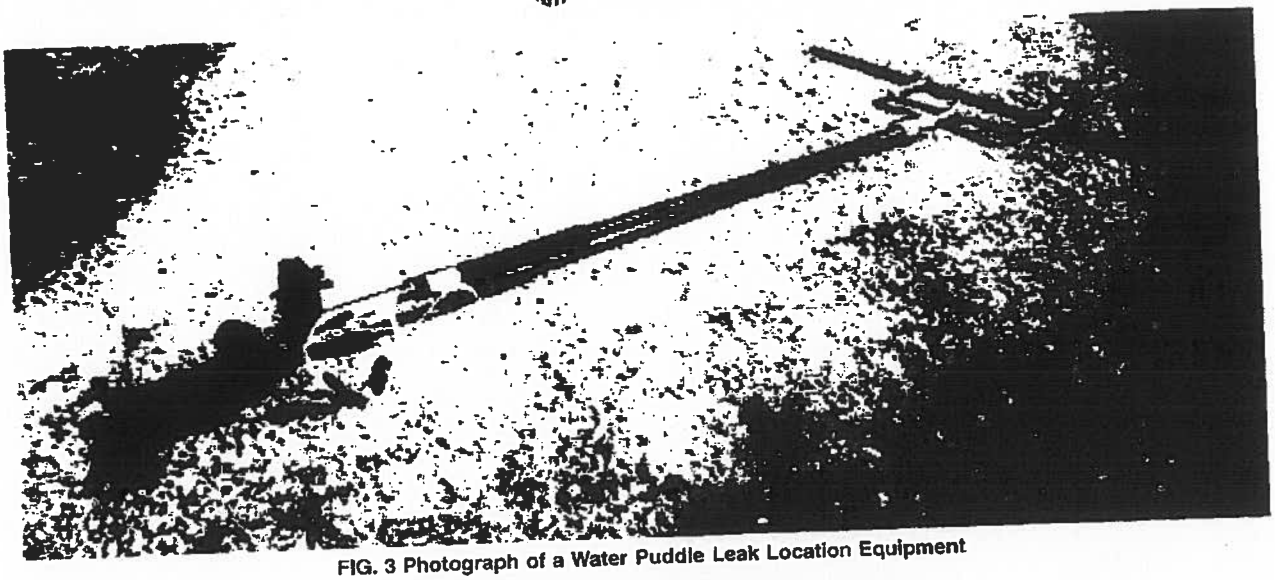


FIG. 3 Photograph of a Water Puddle Leak Location Equipment

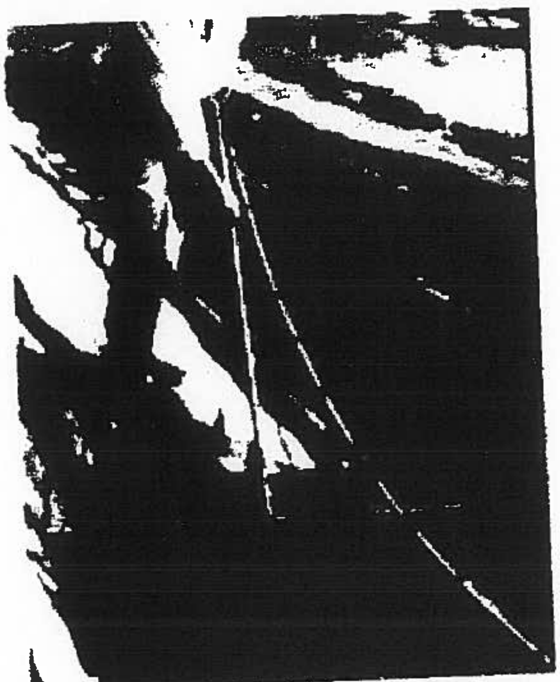


FIG. 4 Photograph of Leak Location Equipment

width of the squeegee from the edge of the geomembrane. The hole should be drilled, and the drill bit reciprocated in the hole so the geomembrane material is removed rather than displaced.

6.4 The excitation power supply and the water supply shall be turned on, and the water puddle detection system shall be pushed over the artificial or actual leak at a speed equal to the desired production survey speed.

6.5 If the resultant signal is at least 10 percent of the full scale reading of the detector electronics, the leak detection equipment and procedures shall be considered to be successfully demonstrated.

6.6 The leak location survey shall be conducted using the same water puddle detection system speed as that used for the calibration.

6.7 Periodic testing of the integrity of the electrical circuit is recommended. It is recommended to check every 15 to 20 min the integrity of electrical circuit by contacting (touching) the subgrade with the equipment squeegee unit or by using an extra electrical cable well-connected to the subgrade. As a minimum, this check shall be conducted at the beginning and end of each day of survey. If the equipment fails to pass the leak detection sensitivity test, then the area surveyed with that set of equipment in the period since the previous leak detection sensitivity test shall be repeated.

7. Report

7.1 The leak location survey report shall contain the following information:

TABLE 1 Specifications—Water Puddle Leak Detection Techniques

geomembranes	HDPE, VLDPE, PVC, fPP, bituminous, CSPE, CPE	✓	applicable
	EPDM, GCL	X	not applicable
	exposed	✓	applicable
	covered	X	not applicable
characteristics	training time		1 day
	set up time and calibration time		1 to 3 h
	measurement time		instantaneous
	leak location time		10 min max
	subgrade moisture (by weight)		equivalent to sand with > 0.7 %
	average survey speed (horizontal surface)		500 m² per hour per operator
	power supply		12 or 24 volts DC or AC
seams	all types: welded, tape,adhesive, glued and other	✓	applicable: project specific
junctions	at synthetic pipes and accessories	✓	applicable: project specific
	at permanent structure	✓	applicable: project specific
survey	during construction phase (installation of GM)	✓	applicable
	after installation (exposed)	✓	applicable
	after soil covering	X	not applicable
	presence of large wrinkles and waves	X	not applicable
	slopes	✓	applicable: project specific
	desiccated subgrade (conductivity equivalent to sand with < 0.7 % moisture)	X	not applicable
	during the service life (if exposed)	✓	applicable
	electrical isolated conductive structures	✓	applicable
climate	sunny, temperate, warm	✓	applicable
	rainy weather, freezing weather	X	not applicable
leak detected	size of 1 mm and larger	✓	applicable
	discrimination between multiple leaks	✓	applicable

7.1.1 Description of the survey site,
7.1.2 Climatic conditions,
7.1.3 Type and thickness of geomembrane,
7.1.4 Liner system layering,
7.1.5 Description of the leak location method,
7.1.6 Survey methodology,
7.1.7 Identification of equipments and operators,
7.1.8 Results of artificial leak test,
7.1.9 Specific conditions of survey,
7.1.10 Location, type and size of detected leaks, and
7.1.11 Map of the surveyed areas.

8. Keywords

8.1 electrical leak location method; geomembrane; leak detection

APPENDIX H

How Much Does my Landfill Leak?

Abigail Beck, M.S., P.E

The question of how much landfills leak might be the most contentious question in the solid waste industry and the one with the most elusive answer. Leakage can be predicted using models of varying levels of sophistication, but modeling relies on accurate data for hole frequency and size. Published statistics for hole size and frequency vary widely and most of the published data is drastically out of date and out of context for construction practices in North America. The prescribed method of monitoring existing landfill leakage through single-lined landfills is through a groundwater monitoring network, but once contamination is detected it is already too late. The only feasible way of remedying the problem may be to cap and close the portions of the landfill that are leaking, which may jeopardize crucial operating revenue. In extreme cases, groundwater remediation may be required, which is costly and may or may not be effective depending on the hydrogeologic conditions. The obvious solution is to build landfill liners that don't leak, but the simple laws of chemistry and physics, not to mention Murphy 's Law, preclude this possibility.

An estimate of landfill leakage is often calculated indirectly using the Bernouilli or Giroud equations if the hole size and frequency are known (Giroud et. al., 1997). Leak frequency and size statistics are generated from the results of geoelectric leak location methods. However, published leak location statistics come from various leak location methods on various applications in many different countries with highly varying and sometimes nonexistent construction quality assurance (CQA). All of these conditions affect leak frequencies greatly. Average hole size and frequency contributing to leakage depends heavily on the skill of the liner installer and the skill of the CQA agency. Several studies have shown the significant reduction in hole frequencies and leakage in the presence of CQA during construction (Forget et. al., 2005, Bonaparte and Gross, 1992). This concept can be expanded to an improvement in construction quality with rigorous CQA as opposed to poor or inattentive CQA. Since standards and minimum experience qualifications are relatively high for landfill expansions in the United States, the average hole frequency is far less for landfill expansions in this country than in most other applications in other parts of the world, in the author's experience. That being said, hole frequency does not always translate directly to leakage rates, since the types of damage typically created during placement of the cover material (gravel, soil, sand), can be far more significant for leakage rates than knife slices or pinholes occurring during liner installation.

Whether or not holes are created by equipment placing cover material depends on the placement method and the care in which the method is executed. It also depends on the quality control of the cover material and whether or not the material has been screened. Finally, it depends on the level of care of the CQA technician watching placement of the cover soil material. Tremendous care is given to the placement of the leachate collection and recovery system (LCRS) drainage layer and operations soil layer over landfill liners. Damage attributed to cover soil placement is rarely found in the landfill industry in the author's geoelectric survey experience of landfill expansion cells since 2004, contrary to old statistics that claim that 74% of liner damage is caused by placement of the cover material (Nosko et al, 1996). When oversized particles are not controlled in the cover soil, punctures can and will happen to a geomembrane (see Figure 1). This photo was taken at a water reservoir.

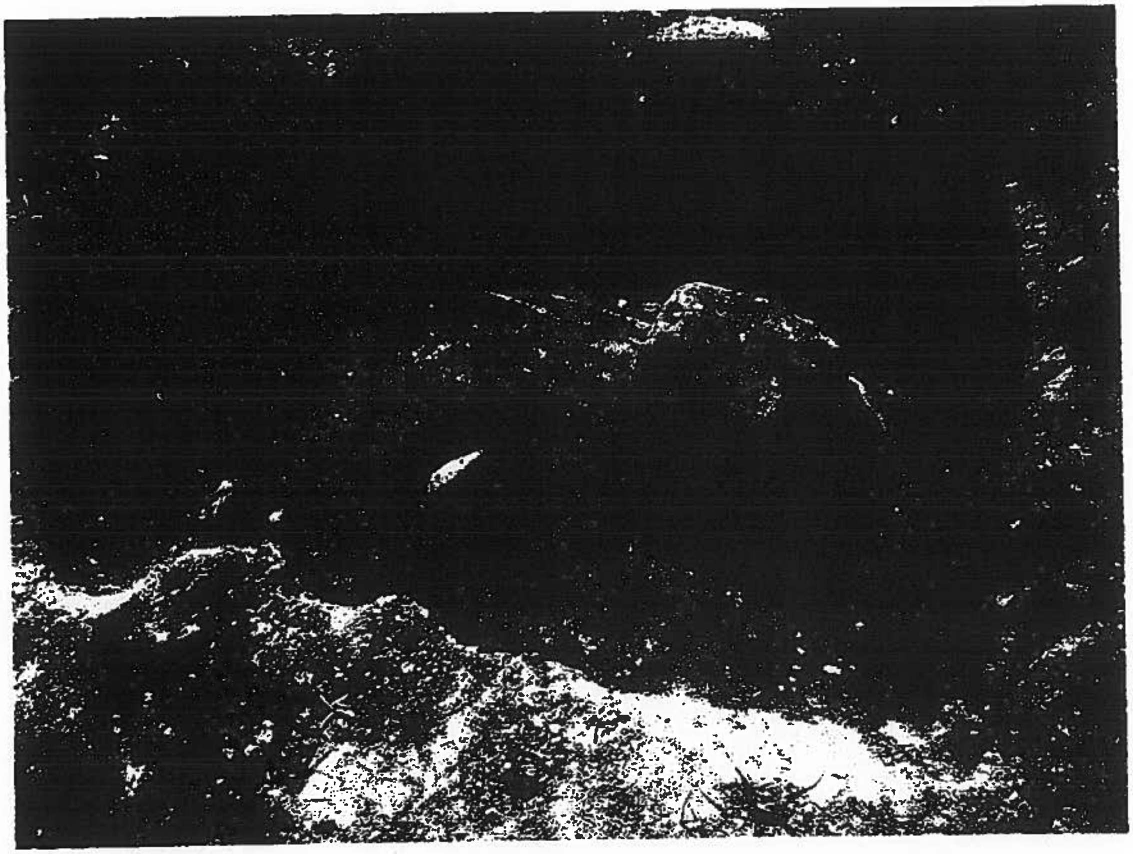


Figure 1: Damage to polypropylene geomembrane from oversized particle found during a geoelectric leak location survey over cover soil at a water reservoir.

Double-lined landfills provide the most accurate measurement of geomembrane leakage because the leakage through the primary geomembrane can be collected and quantified in the secondary containment system. Two published studies provide a comprehensive evaluation of landfill leakage through the primary liner; one study funded by the EPA in 1992 (Bonaparte and Gross, 1992) and a more recent study of leakage in the state of New York (Beck, 2012). The 1992 study showed average leakage data through the primary geomembrane from 14 landfill cells where CQA had been performed during installation. The 2012 study focused on the maximum monthly leakage values, so the published data cannot be directly compared to the 1992 data.

Previously unpublished data of average annual leakage rates from the 2012 study is presented here for the first time, allowing for a direct comparison between average landfill leakage statistics in 1992 and average landfill leakage statistics in 2012. Annual average leakage data from 122 double-lined landfills in the state of New York from the reporting year 2010 was organized into the same leakage bins as the 1992 Bonaparte and Gross study. The percentage of landfills falling within the given leakage rate ranges is shown in Figure 1 from the data collected in 1992 and the data collected in 2012. As a result of advances in installation quality and CQA practices, leakage rates greater than 50 liters per hectare per day (lphd) have decreased significantly in the past 20 years. It is therefore inappropriate to rely on old leakage data for estimating leakage through geomembranes using modern construction techniques

	Percentage of Landfill Cells	
Leakage Rate (lphd) [b]	1992 [a]	2012 [a]
<50	43%	72%
50 - 200	36%	25%
200 - 500	14%	3%
500 – 1,000	7%	0%
>1,000	0%	0%

Table 1: Distribution of Average Landfill Leakage Rates

[a] Year Data was published

[b] Liters per hectare per day; 1 gpad = 9.3 lphd

The best available technology for locating leaks in geomembranes before they become a problem is geoelectric leak location methods, also known as liner integrity surveys. These methods are covered by ASTM methods D6747, D7002, D7007 and D7703. The methods for exposed geomembranes (ASTM D7002, D7703) can be used to locate holes in the geomembrane immediately after geomembrane installation. The bare geomembrane methods are sensitive enough to locate pinholes. The dipole method (ASTM D7007) is used after placement of the cover materials. Ideally, a bare geomembrane method would be used after geomembrane installation, then the dipole method would be used after placement of the cover materials. In this way, the very small holes created during liner installation could be located and repaired, then the dipole survey can locate any holes that might have been created during cover soil placement.

The 2012 landfill leakage study (Beck, 2012) provides a statistical approach to quantifying landfill leakage by calculating the probability of exceeding a given leakage rate in three cases: 1) if no geoelectric leak location survey is performed, 2) if only a dipole survey is performed, and 3) if both a bare geomembrane survey and a dipole survey are performed. The input parameters such as hole size and frequency used in the Bernoulli equation to calculate the probabilities were calibrated by the actual maximum monthly leakage data for landfills with and without dipole surveys performed as part of construction. Since the focus of the study was landfills in New York State, the probability of exceeding the state's Action Leakage Rate (ALR) of 20 gallons per acre per day (gpad) was calculated. The Action Leakage Rate is defined as the leakage rate at which a site will be required by the state to take action to repair the problems causing the leakage. Along with using modern construction methods and a rigorous CQA program, the results of the analysis showed that there is a 22.2% probability of exceeding the ALR if no survey is performed, a 7.1% probability of exceeding the ALR if only the dipole method is performed and a probability of 0.00001% of exceeding the ALR if both the bare geomembrane and dipole methods are performed.

ALRs vary from state to state but unless a landfill is completely double-lined, there is no way to immediately measure how much a single-lined landfill is leaking. Sites can only mitigate future risks by creating good specifications, upholding standards, hiring reputable installers and CQA agencies, and specifying a geoelectric leak location survey as a final check for liner integrity.

Biography: Ms. Beck is a Senior Engineer and Director of the Liner Integrity Services Division of TRI Environmental, Inc. She has over eight years and 70 million square feet of geoelectric leak detection survey experience and has authored over a dozen technical papers and articles.

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APPENDIX I

GEOMEMBRANE LINER FAILURE: MODELLING OF ITS INFLUENCE ON CONTAMINANT TRANSFER

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ABSTRACT: : The statistical results of the electrical damage detection system installed at more than 300 sites covering more than 3.250.000 m^2 are presented with respect to the cause of the damage vs. size of damage and location of damage respectively. Another important result is that in cases of more than a few membrane failures per one site, the distribution of damage is not regular. The failures generally amalgamate in specific areas located irregularly in the geomembrane liner: flat floor areas, edges, corners, penetration of geomembrane, end of road access, joint of slopes and bottom, seams, temporary storage of granular materials, areas of loading and unloading of such materials, areas of regular motion of heavy plants, etc. The mathematical modeling based on such statistical results show very important information. The main critical parameters are the location of failures and then a density of their occurrence. The size of a hole (even though it may look very critical in time when it is revealed) is less important than previous ones. These results point out the fact that in order to adequately quantify the rate of liquid flow through a composite liner, more information than the density of holes in the geomembrane is needed. Indeed, it is necessary to know the exact position of the holes, and their relative positions with regard to the position of wrinkles in the geomembrane. These results are only partial ones and the research continues.

Keywords: Geomembrane, Leak detection, Monitoring, Quality control, Wrinkles.

1 INTRODUCTION

Every single day of our lives has significant value. Everyday we surround ourselves with critical actions, which decreases life's value. We strongly depend on the environment and its contamination decreases our chance to live longer. It was not long ago when a scientist discovered that a clay layer between dangerous material and subgrade is not enough protection and that some other synthetic impermeable material should be used. Geomembranes appear to be the best material for the separation of dangerous, toxic solids and liquid materials. While knowledge of quality installations of geosynthetic layers increases, the problem of their integrity after the installation appears to be a crucial factor in their overall usefulness.

During our active work in the field of geosynthetics, and our active contributions during conferences, meetings, etc., we discovered that the subject of the quality of geomembrane installation is discussed everywhere. It has been only a few years since electrical leak detection and location methods have become commercially used as a tool for deciphering some information regarding the integrity of the geomembrane after installation and placing protection on the top of their surface. Several authors have presented their results and some of them (Laine, Darilek 1993; Crozier, Walker 1995; Nosko et al. 1996 etc.) bring very useful contributions to highlight the problem. Since then, more and more people have been involved in such a business to answer the question "How dangerous it is to leave the damage unrevealed and not repaired?".

2 ANALYSES OF GEOMEMBRANE LINER FAILURES

Therefore, based on such indications, we started to create and study some statistical data mainly obtained by SENSOR DDS® technology. This technology has been widely used in the last ten years for in-situ monitoring of the integrity of geomembrane liners. During that period we have been collecting and analyzing data from several thousand failures from 16 countries, which represents more than 300 sites and approximately 3.250.000 m^2.

This study was performed based on three criteria: position of damage, size of damage, and cause of damage. The obtained data are shown in tables as a function of location of damage and cause of damage versus size of damage, respectively (see Table 1 and 2).

One of the main purpose of this study is to present the distribution details of damage throughout the controlled area. We have discovered that in cases of multiple holes, the cause of the damage can be grouped in several common categories which are defined below in Table 1. In addition, we would like to highlight the relationship between the location and cause of the damage inside the same inspected area. The controlled area is divided into 5 regions representing the typical locations of the landfill cells and for our identification purpose. (see Figure 1).

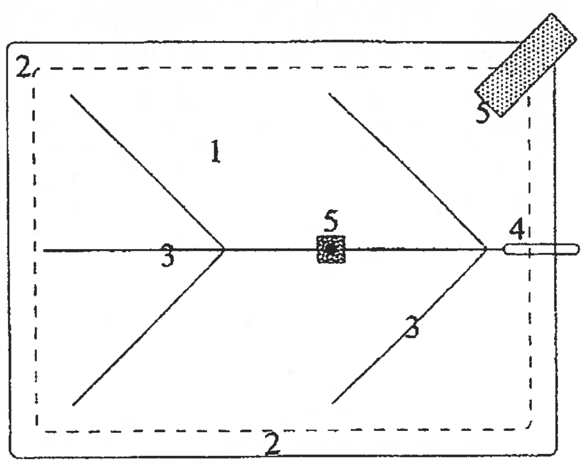

Figure 1. Schematic view of a landfill with the numbering of the parts.

One can easily notice that the majority of damage were caused by stones within the protection layer and heavy equipment (bulldozer, caterpillar, front loader, etc.). Engineers as well the site workers and operators should be able to make proper provisions to minimize these types of damage occurring.

Another very important fact that we discovered was that the most failures were located within flat areas (#1) where again stones and heavy equipment caused the majority of failures.

We can see slightly different pattern in other areas like corners and drainage areas such that more damage caused by extrusion welds and by heavy equipment are noticed. However, the damage due to the stones are the key contributor of the damage.

It is understandable that the other results we obtained in the case of pipe penetrations through a geomembrane were comprised mostly of failures of extrusion welds.

Regarding damage done by various sizes of stones, we found the problem of counting the exact amount of single holes. Mostly the damage by stones occur as one typical area with several (sometimes tens) small and single holes grouped together. Hence, we adopted an idea that a single hole caused by the stones is defined as an area with holes are clustered together within 5 cm diameter region. If another group of holes clustered is separated by more than 5 cm, we would consider that as a separate hole.

Table 1. Cause of damage vs. size of damage

Size of dam. (cm^2)	Stone	%	Heavy equipment	%	Welds	%	Cuts	%	Worker directly	%	Total
< 0.5	332	11.1	-	-	115	43.4	5	8.5	-	-	452
0.5 – 2.0	1720	57.6	41	6.3	105	39.6	36	61.0	195	84.4	2097
2.0 – 10	843	28.2	117	17.9	30	11.3	18	30.5	36	15.6	1044
>10	90	3.0	496	75.8	15	5.7	-	-	-	-	601
Amount	2985		654		265		59		231		4194
Total	71.17 %		15.59 %		6.32 %		1.41 %		5.51 %		

Table 2. Location of damage

Amount of damage	Flat floor 1*	Corner, edge, etc. 2	Under a drainage pipes 3	Pipe penetration 4	Other 5**
4194	3261	395	165	84	289
100 %	77.8 %	9.4 %	3.9 %	2.0 %	6.9 %

* (see plan view of model landfill pond)

** (road access, temp. storage, concrete structure, etc.)

The tables from 3 to 7 show the analysis of the cause of the damage vs. location. Such information is very useful to help understand what goes on at the landfill construction sites in terms of the geomembranes.

Table 3. Flat floor

Type of failure	Amount of holes	%
Stones	2641	81.00
Heavy equipment	430	13.20
Worker	130	4.00
Cuts	33	1.00
Welds	26	0.80
Total	3261	100.00

Table 4. Corner, edge, etc.

Type of failure	Amount of holes	%
Stones	234	59.20
Heavy equipment	75	18.90
Worker	14	3.50
Cuts	4	0.90
Welds	69	17.50
Total	395	100.00

Table 5. Under a drainage pipes

Type of failure	Amount of holes	%
Stones	50	30.30
Heavy equipment	24	14.30
Worker	24	14.50
Cuts	23	13.70
Welds	45	27.20
Total	165	100.00

Table 6. Pipe penetration

Type of failure	Amount of holes	%
Stones	-	-
Heavy equipment	-	-
Worker	7	8.50
Cuts	1	0.60
Welds	77	90.90
Total	84	100

Table 7. Other (road access, temp. storage, concrete structure, etc.)

Type of failure	Amount of holes	%
Stones	60	20.60
Heavy equipment	125	43.40
Worker	56	19.30
Cuts	-	0.00
Welds	48	16.70
Total	289	100.00

3 ESTIMATION OF THE RATE OF LIQUID FLOW DUE TO HOLES IN GEOMEMBRANE OF COMPOSITE LINERS

3.1 *Assumptions*

The general liner system considered (Figure 2) follows from Rowe (1998) and Touze-Foltz et al. (1999) and includes a geomembrane resting on a low-permeability clay liner of thickness H_L and hydraulic conductivity k_L. The z-axis origin corresponds to the top of the soil liner with upward being positive. It is assumed that the geomembrane is not in perfect contact with the soil liner and that there is a uniform transmissive zone between the geomembrane and the soil liner surface that is referred to as the "transmissive layer". In the following, it is assumed that: (i) liquid flow is under steady state conditions; (ii) the soil liner and the foundation layer are saturated; and (iii) liquid flow through the liner is vertical.

Analytical solutions have been developed by Touze-Foltz et al. (1999) for the axi-symmetric (circular hole in flat surface of geomembrane) and two-dimensional (hole in a wrinkle) cases as presented on Figure 2. These solutions will be used in the following to quantify the influence of the hydraulic head and of the size of the hole on the rate of liquid flow either for the axi-symmetric and two-dimensional cases. No particular assumptions are made regarding the dimension, position, or the number of holes in the wrinkles, but rather it is assumed that the rate of liquid flow in the composite liner is not limited by the holes (the hole limiting case is discussed by Rowe (1998) and Touze-Foltz et al. (1999)).

In the following calculations, the values of hydraulic conductivities of CCLs and of hydraulic transmissivities of the transmissive layer between CCLs and geomembranes given by Rowe (1998) are adopted. Two values of hydraulic transmissivities are used for the transmissive layer between geomembranes and CCLs: The first one is $\theta = 1.6\times10^{-8}$ m^2s^{-1} when the hydraulic conductivity k_L of the CCL is equal to 10^{-9} ms^{-1}. This hydraulic transmissivity corresponds to "good contact" conditions as defined by Giroud (1997) in developing his semi-empirical equations (Rowe 1998). The second one is $\theta = 10^{-7}$ m^2s^{-1} when the hydraulic conductivity k_L of the CCL is also equal to 10^{-9} ms^{-1}. This hydraulic transmissivity corresponds to "poor contact" conditions as defined by Giroud (1997). It can correspond to the transmissivity obtained in case a geotextile is put in the transmissive layer.

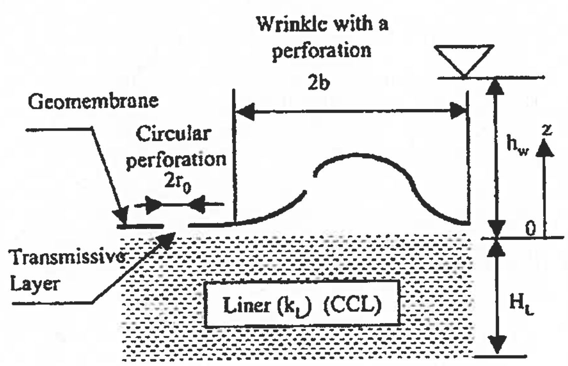

Figure 2 : Schematic showing a hole of radius r_0 and a wrinkle with a perforation in a geomembrane and the underlying stratum (modified from Rowe, 1998 and Touze-Foltz et al.,1999)

The liner thickness which is not an important parameter in determining the rate of liquid flow is set equal to 1 m.

The hydraulic head h_w on top of the composite liner is varied from 0.03 m to 3 m, to test the influence of the position of the hole (distance to the leachate sump). The hole area is varied from 0.1 cm^2 to 10 cm^2 according to data presented previously.

The boundary condition at the downstream end of the transmissive layer will be referred to as field boundary conditions. It corresponds to a zero-flow and zero-hydraulic head and is the limit of validity of solutions developed by Touze-Foltz et al. (1999).

3.2 *Results obtained*

3.2.1 *Axi-symmetric case*

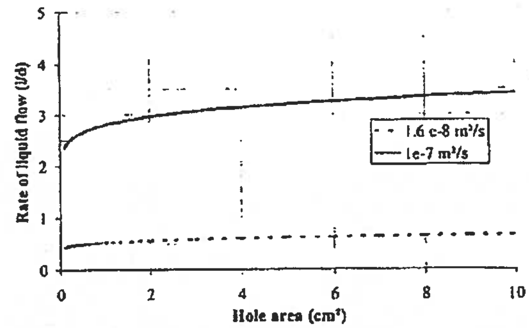

Figure 3: Evolution of the rate of liquid flow with the hole area, for the two values of hydraulic transmissivities adopted for the axi-symmetric case

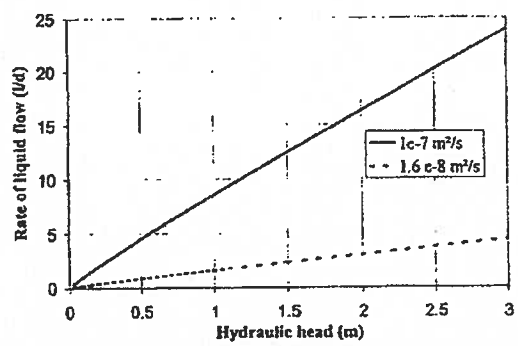

Figure 4: Evolution of the rate of liquid flow with the hydraulic head, for the two values of hydraulic transmissivities adopted for the axi-symmetric case

Figure 3 Shows the evolution of the rate of liquid flow obtained for a single hole for both values of hydraulic transmissivities adopted. The hydraulic head on top of the composite liner was equal to 0.3m for the calculations performed. One can notice that the hole size is not the influent parameter on the rate of liquid flow, whatever the value of hydraulic transmissivity. As shown on Figure 3 the hydraulic head is a much more important parameter. Indeed, the rate of liquid flow is nearly proportional to the hydraulic head applied on top of the composite liner. As a result, it seems that as far as circular holes are concerned, it is much more important to perfectly know their location than their size in order to adequately estimate the rate of liquid flow through the composite liner.

One can notice as well on Figures 3 and 4 that an increase in the hydraulic transmissivity by a factor close to 5 results in an increase in the rate of liquid flow by nearly the same factor. As a consequence, the use of a geotextile in the transmissive layer resulting in an increase of the hydraulic transmissivity may not be a convenient practice as it will significantly contribute to increase the rate of liquid flow. More research is needed to clarify this point and especially to quantify the hydraulic transmissivity of the transmissive layer at field scale.

3.2.2 *Two-dimensional case*

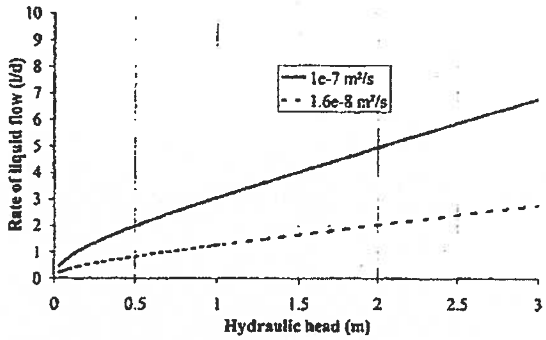

Figure 5: Evolution of the rate of liquid flow with the hydraulic head, for the two values of hydraulic transmissivities adopted for the two-dimensional case

For calculations performed assuming a damaged wrinkle in the geomembrane, the width of wrinkle adopted was 0.2 m. Figure 5 shows the rates of liquid flow obtained as a function of the hydraulic head applied on top of the composite liner. The evolution of the rate of liquid flow (given here for a meter of wrinkle) with the hydraulic head is nearly linear, especially for hydraulic heads greater than 0.5 m. The rate of liquid flow is less sensitive to an increase in the hydraulic transmissivity than in the axi-symmetric case. Indeed, the increase from a value of θ equal to 1.6×10^{-8} m^2s^{-1} to a value of θ equal to 1.6×10^{-8} m^2s^{-1} results in a increase by a factor 2.5 of the rate of liquid flow.

These results point out the fact that in order to adequately quantify the rate of liquid flow through a composite liner a density of holes in the geomembrane is not a sufficient information.

Indeed, it is necessary to know the exact positions of holes, and their relative positions with regard to the position of wrinkles in the geomembrane.

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APPENDIX J

Available Technologies to Approach Zero Leaks

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ABSTRACT

Field-proven technologies are currently available for reducing leakage through installed geomembranes, which are cost effective and non-disruptive to a typical geomembrane construction schedule. These technologies include electrical leak location (ELL) methods and wrinkle management strategies. ELL methods are optimized by employing wrinkle reduction or elimination strategies. A design tool for estimating the effectiveness of ELL technologies, alone or in tandem with wrinkle reduction and elimination, has not previously been presented. This paper takes a deep look at the actual leakage reported through the installed primary geomembrane of double-lined landfills and the equations used to estimate geomembrane leakage. Backed by landfill leakage statistics and case studies, a novel design approach is presented for estimating anticipated leakage after the implementation of the technologies presented. The leakage estimations take into account the limitations of each available technology. With accurate estimations of anticipated leakage, the probability of exceeding a given action leakage rate (ALR) can then be calculated. The probabilities of exceeding a given ALR is presented for the use of the following; a dipole method ELL survey, a bare geomembrane survey followed by a dipole method ELL survey, a bare geomembrane survey followed by dipole method ELL survey where wrinkles have been reduced by 10%, and a bare geomembrane survey followed by a dipole method ELL survey where wrinkles have been eliminated completely. Design guidelines are presented for sites aiming to use the aforementioned technologies to confidently achieve leakage volumes of less than 187 liters per hectare per day (lphd) (20 gpad), 46 lphd (5 gpad), and less than 46 lphd.

1. INTRODUCTION

1.1 Action Leakage Rates

A subsurface water body can only receive a certain amount of contamination before groundwater quality is impacted. The concept of the Action Leakage Rate (ALR) was created in order to set a limit to the amount of leakage allowed from a containment facility. Once the ALR is exceeded, a site must take action to remediate the leakage problem before the site is allowed to continue operations. The establishment of a state or site-specific ALR should address the allowable quantity of contaminant leakage from a containment facility before groundwater is impacted. In the 1990's, the U.S. EPA attempted to establish an ALR for landfills of a few gallons per acre per day (gpad) with this goal in mind (Lee, 1996). Shortly thereafter, a survey of actual leakage through double-lined containment systems by Bonaparte and Gross showed that with the construction practices at the time, it would be technically unfeasible to achieve such a low leakage rate, since actual leakage rates through installed geomembranes were observed to be much higher.

The U.S. EPA does not mandate specific ALRs for various impoundments; rather it requires that individual states establish ALRs for given containment facility types. Environmental regulators in the state of New York understand the correlation between the mandated ALR and the actual leakage that could impact groundwater. New York State requires that municipal solid waste landfills be composed of double composite lining systems. The New York State ALR of 187 lphd (20 gpad) applies to the primary geomembrane. The leakage through the primary geomembrane can be monitored for compliance by the leak detection system. Using the leak detection system flow rate as the driving hydraulic force through the secondary geomembrane, there should be very little flow (less than 1 gpad if any) through the secondary geomembrane, the critical final barrier for groundwater protection. This theory is corroborated by actual monitoring data collected from the pore pressure relief drainage systems installed in about 70% of the landfills in New York State. The monitoring data collected from these comprehensive systems have shown no impact to groundwater quality. For landfills in many of the other forty nine states, most with single composite lining systems, the story is quite different.

1.2 Factors Contributing to Leakage

Many factors can contribute to geomembrane leakage including the number and size of holes, the presence of wrinkles, the depth of waste, the cover system (if in place), the barrier system components, the leachate collection system design, the nature of the barrier system foundation, the nature of the waste and the leachate collection system operation and maintenance (Rowe and Hosney, 2010). By far the biggest factor contributing to leakage are the actual holes in the geomembrane; system design and operation can only mitigate or exacerbate the principal problem of leaks. A comparison of leakage resulting from leaks with intimate contact with the underlying GCL, compared with leakage resulting from leaks on a wrinkle shows that the presence of wrinkles can significantly compound the problem of holes

(Rowe and Hosney, 2010). Wrinkles can also increase the probability of creating holes during cover material placement, since even GPS-controlled equipment could catch the peak of a wrinkle, which could be significantly above base grades. This paper therefore focuses on the technologies for directly avoiding both leaks and wrinkles during the construction phase, since the presence of both leaks and wrinkles work in combination to create the largest risk for exceeding a given ALR throughout the life of a site.

1.3 Leakage Rate Calculations

Probably the most commonly used equation for calculating leakage resulting from a hole in a composite lining system is the Giroud equation (Giroud, 1997). However, this equation is only applicable for leaks maintaining intimate contact with the subgrade material. Although leakage equations for holes on wrinkles have been available for some time, only recently has the field geometries and hydraulic network of wrinkles been extensively quantified (Chappel, 2012, Rowe et al., 2012). The recent evaluations of wrinkle extent and geometries provide the necessary input parameters to apply to the Rowe equation. As installed geomembranes receive solar radiation they begin to expand, resulting in the formation of wrinkles. Evaluations of wrinkles in exposed geomembranes show that up to 30% of the geomembrane area may be covered by hydraulically connected wrinkles (Chappel, 2012). This means that if there is a hole anywhere within that wrinkled area, the network of wrinkles can provide a hydraulic conduit for liquid that has migrated through the geomembrane. For that portion of the geomembrane, the only remaining barrier is the GCL, and the resulting leakage can be several magnitudes greater than a single hole maintaining intimate contact with the GCL. Forensic evaluation has shown that wrinkles do not disappear when the geomembrane is subsequently covered with soil (Koerner and Koerner, 2013). Rather, the wrinkles are entombed in place. Leakage rate calculations must therefore take into account both the leak density and the extent of geomembrane wrinkling.

1.4 Leakage Rate Data

Quantifying actual leakage from the primary geomembrane of existing double-lined landfills provides the most accurate means of assessing actual geomembrane leakage rates. Correlations between theoretical and actual leakage have been performed (Rowe, 2005, Rowe and Hosney 2012), however the hole frequencies used in those studies were based on leaks located by ELL surveys and the data used is over a decade old. It is well documented that liner integrity surveys have difficulty locating leaks in poor contact conditions such as wrinkles, which will bias the published hole frequency statistics (ASTM D7002, ASTM D7703, ASTM D7953 and ASTM D7007). Due to New York State's requirement for double-lined landfills and annual reporting of leakage through the primary geomembrane, actual leakage data can be collected and analyzed. Although this is the most accurate way of obtaining leakage data, it is still prone to inaccuracies due to; leakage caused by condensation and/or vapor diffusion through an intact geomembrane, potential liquid migration to the leak detection layer along the perimeter anchor trenches and measuring frequency.

The required measuring frequency from the leak detection layer varies by state. Although units of gpad are reported, the volumetric leakage measurements are not taken daily. This allows a site to average out any peak values that may have occurred from day to day. Some states allow weekly averaging, while others allow monthly averaging. A weekly average will result in a higher reported maximum leakage rate than a monthly average. New York State allows monthly averaging, so the values published here are certainly a significant underestimation in comparison with states that only allow weekly averaging.

Leakage rate data was analyzed from 122 discrete landfill cells, where no ELL survey was reported to have been performed. It should be noted that the data collected is from New York State for the reporting year 2010, where dipole ELL surveys have been specified for some time. Therefore, most of the leakage data for cells without an ELL survey are from older landfill cells where the waste is now very thick and the cells might even be capped. When older leakage data is investigated, much larger leakage rates are discovered for cells which reported extremely low leakage rates for the reporting year 2010. For example, one cell reported a leakage rate of 1,396 lphd (149.3 gpad) in 1998, but a leakage rate not exceeding 35.5 lphd (3.8 gpad) for any of the reporting years 2006 through 2012. Reviewing data from new cells is typically significantly higher than subsequent years and tends to increase on a downward trend as the cell ages due to the increasing depth of waste. Less liquid is able to migrate through the waste as it gets thicker. Leakage rates for newly constructed cells without a dipole survey performed are therefore not currently available. This data should therefore be considered a considerable underestimation of leakage for newly constructed cells without a dipole survey.

Leakage rate data was analyzed from 60 discrete landfill cells in New York State, where a dipole method ELL survey was performed. The data was collected from reporting years 2006 through 2012.

The average leakage rate for a landfill cell without a dipole survey was calculated to be 124.4 lphd (13.3 gpad). The average leakage rate for a landfill cell with a dipole survey was calculated to be 69.2 lphd (7.4 gpad). Histograms of the leakage data are shown in Figures 1 and 2.

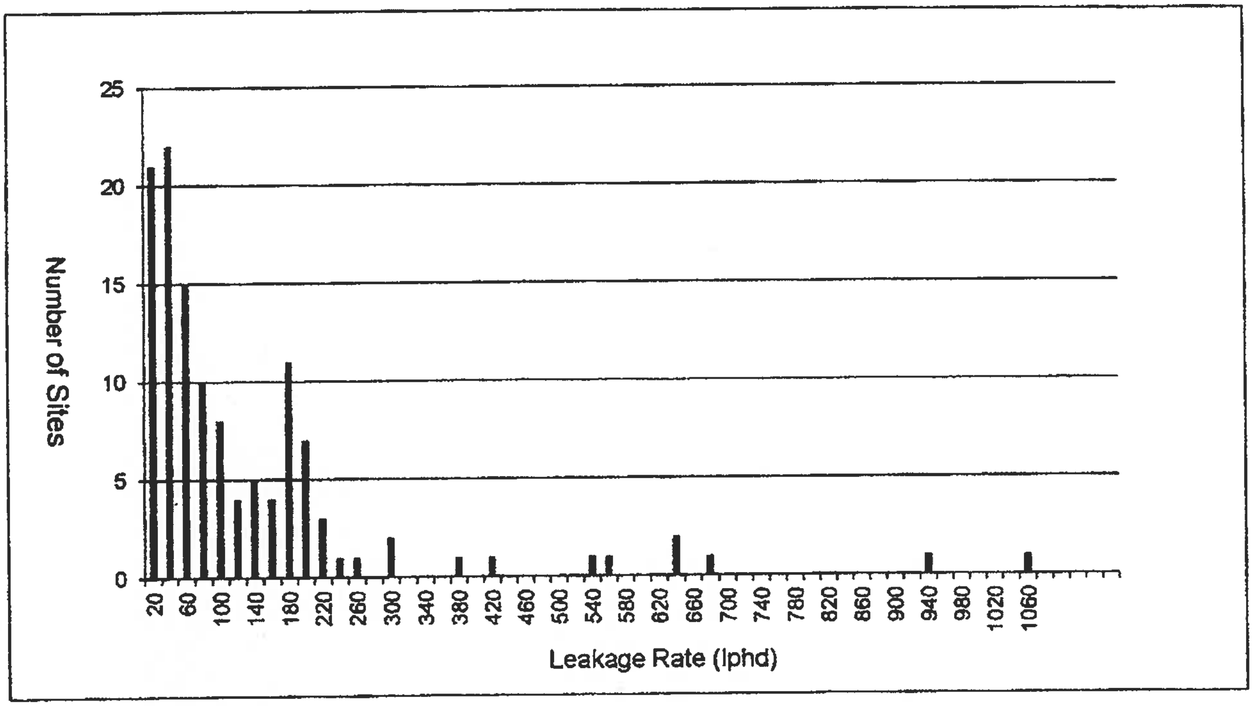

Figure 1. Leakage Rates without ELL survey. Leakage Rate statistics for double-lined landfills in New York State for reporting year 2010; data set from 122 discrete landfill cells, where no ELL survey was reported

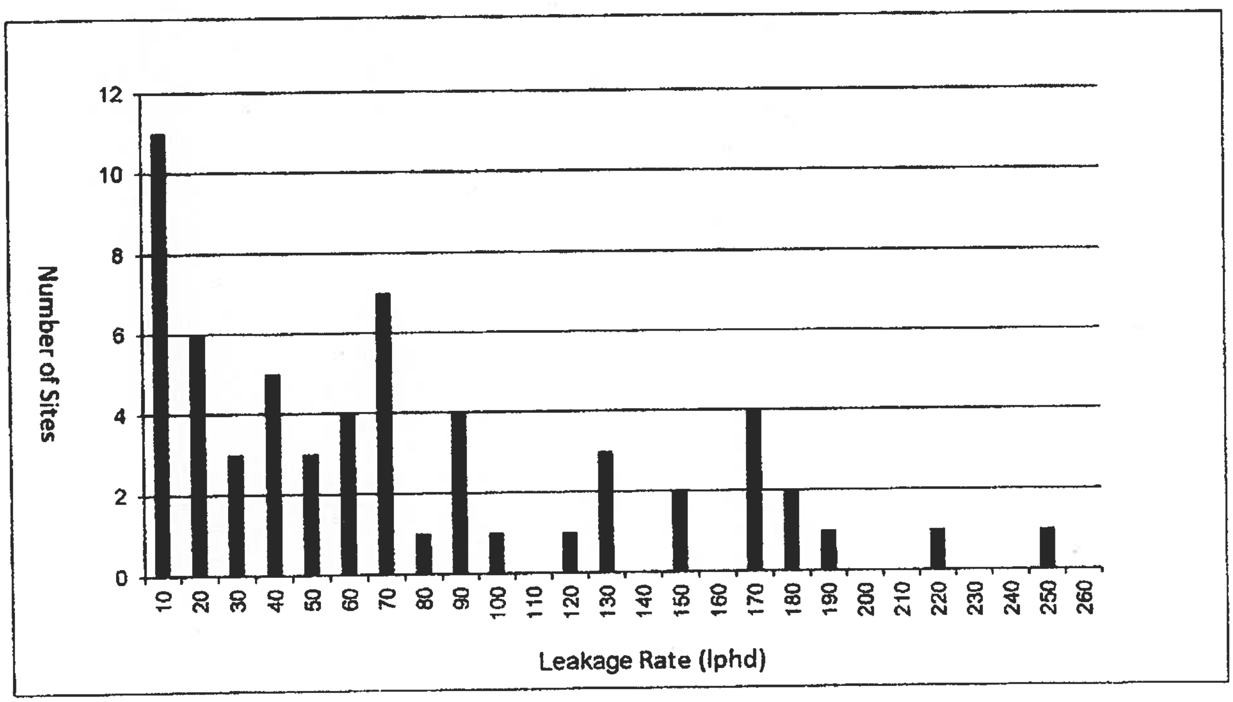

Figure 2. Leakage Rates with dipole ELL survey. Leakage rate statistics for double-lined landfills in New York State for reporting years 2006-2012; data set from 60 discrete landfill cells, where dipole ELL survey was performed as part of construction.

1.5 Available Technologies

The available technologies for reducing leakage presented herein can be economical, effective, and non-disruptive to the rigorous construction schedule of landfill construction. The benefit of each of these technologies in terms of decreasing geomembrane leakage is also quantifiable. The performance of an ELL survey directly locates existing leaks for repair. The reduction in leakage by performing an ELL survey can be deduced by measuring actual leakage through the primary geomembrane for cells with and without an ELL survey. The limitations of ELL technology include the inability to locate a leak on a wrinkle or other poor contact condition. The potential extent of wrinkling is quantifiable through field-scale studies of wrinkle development as a function of increasing geomembrane temperature (Koerner and Koerner, 1995 and Rowe et. al, 2012). The ELL methods can be optimized through wrinkle reduction or elimination strategies. Each technology is discussed in detail below.

ELL surveys for landfill expansions can be divided into two categories; bare geomembrane surveys and soil-covered dipole surveys. The bare geomembrane survey is performed directly after geomembrane installation and can locate the smallest leaks caused during geomembrane installation. The soil-covered dipole survey is then used to locate any leaks created during placement of the cover soil material. The bare geomembrane methods are generally much more sensitive than the soil-covered dipole method. The soil-covered dipole method will not likely find pinholes, knife slices, or other small damage locations created during geomembrane installation. However, most landfills only perform the dipole method for landfill expansions when ELL is required or specified for a site because the most significant damage is typically caused during cover soil placement.

The bare geomembrane methods include the water puddle, water lance and arc testing methods. The water puddle and water lance utilize either a puddle or a stream of water to conduct electricity, as the names imply. The electrical current source is grounded to the subgrade underneath the geomembrane. In the presence of a poor contact condition such as a wrinkle, the water may not be able to travel through the hole and down the underside of the wrinkle to complete the electrical connection with the subgrade. The arc tester does not rely on water to conduct electricity; it imposes a high voltage over the geomembrane and is grounded to the subgrade. However, an electrical arc will not form if the arc tester probe is too far away from the subgrade, as would be the case over a wrinkle. For both methods, effort is made to push down the wrinkles, or the survey is performed at night. However, the risk remains due to the technological limitations of the methods that leaks can be missed on wrinkles and other areas of poor contact.

The soil-covered geomembrane dipole method is similar to the bare geomembrane methods in that a positive voltage is introduced above the geomembrane and grounded to the subgrade beneath the geomembrane. The current source is placed in the soil cover material and current will travel through any leaks in the geomembrane, which have good contact with the subgrade below it. A hole located on a wrinkle entombed in the soil cover simply will not be detected because the electricity will not travel through the air gap created by the wrinkle.

Wrinkle reduction strategies include several techniques, with some of them costly and time-consuming and others much more economic and practical. One of the more labor intensive and time consuming techniques includes the placement of only one geomembrane panel at a time, and then fixing each end with a berm. Another less economic technique is to install a temporary tent, which can be moved over the active placement area, blocking incoming solar radiation during the geomembrane installation process. More practical solutions include limiting the placement of the cover soil to the cool hours of the day and using the "push/accumulate/cut/seam" technique. The option that is the least disruptive to the construction schedule is the use of white geomembrane. White geomembrane can significantly decrease the surface temperature of an exposed geomembrane (Koerner and Koerner, 1995). The lower geomembrane temperature results in a smaller area of the geomembrane covered by wrinkles (Rowe et. al, 2012). The fewer the wrinkles present, the less likely the resulting lining system will contain a hole on a wrinkle that may not be detected by ELL methods.

Wrinkle elimination is extremely difficult to achieve, and may be achieved by using some of the wrinkle reduction strategies discussed in the previous section. However, wrinkles can be "virtually" eliminated through manipulating site conditions or using specialty geosynthetics. These methods are considered "virtual" wrinkle elimination, since the wrinkles are still actually present in the geomembrane; they just no longer pose a limit to ELL surveys. One option is to flood the geomembrane during the performance of the ELL survey. The level of head over the geomembrane must exceed the height of any wrinkles present and the water must fill any voids present underneath the geomembrane. This may or may not be practically achieved in the field. A more reliable option to virtually eliminate the wrinkles is by using conductive-backed geomembrane. Conductive-backed geomembrane is fabricated using the coextrusion process. An electrically insulative HDPE geomembrane is coextruded with an electrically conductive material on the back side as a continuous layer. This results in a conductive layer in intimate contact with the geomembrane. This enables the location of leaks in poor contact conditions such as wrinkles, under the overlap of a fusion weld, or in a location where there is a depression in the subgrade, since the current of the survey is carried by the backside of the geomembrane, removing the need for intimate contact with the subgrade.

2. LEAKAGE RATE DESIGN CALCULATOR

2.1 Calibrating existing equations

Existing equations for estimating leakage through geomembranes caused by holes must be validated for their applicability to large-scale applications. The most realistic leakage rates for actual geomembrane installations are obtained from quantifying the leakage to the leak detection layer, as detailed in Section 1.4. A 2013 case study took this concept one step further and analyzed the leakage from the leak detection layer at a site where dipole surveys were conducted both before and after flooding the primary geomembrane and leak detection layer (Beck, 2014). This allowed for the quantification of leakage through holes located in areas of poor contact. Quantifying the leakage from the leaks that were detected only while the geomembrane was flooded provided evidence that poor contact is an issue for ELL surveys. The case study also allowed for calibrating the Rowe equation in order to arrive at realistic assumptions.

The 2013 case study showed that using the Giroud equation for both good and poor contact between the geomembrane and the GCL, the calculated leakage was over ten times less than the actual leakage recorded. If the holes located are assumed to have been on wrinkles, which would explain why they were not located by the initial dipole survey, the calculated leakage using the Rowe equation fits very well with the actual leakage rate measured from the leak detection layer. The variables used for the Rowe equation in order to match the actual leakage measured included a wrinkle width of 0.31 meters and a wrinkle length of 190 meters. These values are corroborated by field studies of wrinkle formation in large-scale geomembrane installations (Rowe, 2012). Therefore, for a typical geomembrane installation in North America, the Rowe equation should be used to estimate leakage rather than the Giroud equation, which is likely only applicable at sites were extensive measures are taken to create intimate contact.

2.2 Probability Analysis

A probability analysis was introduced by Beck (Beck, 2012) in order to determine the probability of exceeding the New York State ALR when either no ELL survey is performed or a dipole ELL survey is performed. This paper takes that approach further by applying the same statistical analysis to all of the technologies presented in the previous section.

The probability function presented by Beck is as follows:

$$Y(x) = \exp[(-1/\text{mean}) \cdot x] \qquad [1]$$

where Y(x) yields the probability of a leakage rate exceeding a specified ALR, mean is the average leakage rate, and x is the specified ALR.

An excellent correlation is observed in Figures 3 and 4 between the probability function expressed in equation [1] (probability on y-axis of exceeding a given leakage rate on x-axis) and the data analyzed (actual percentage of landfills on y-axis exceeding a given leakage rate on x-axis) for both of the data sets presented in Section 1.4.

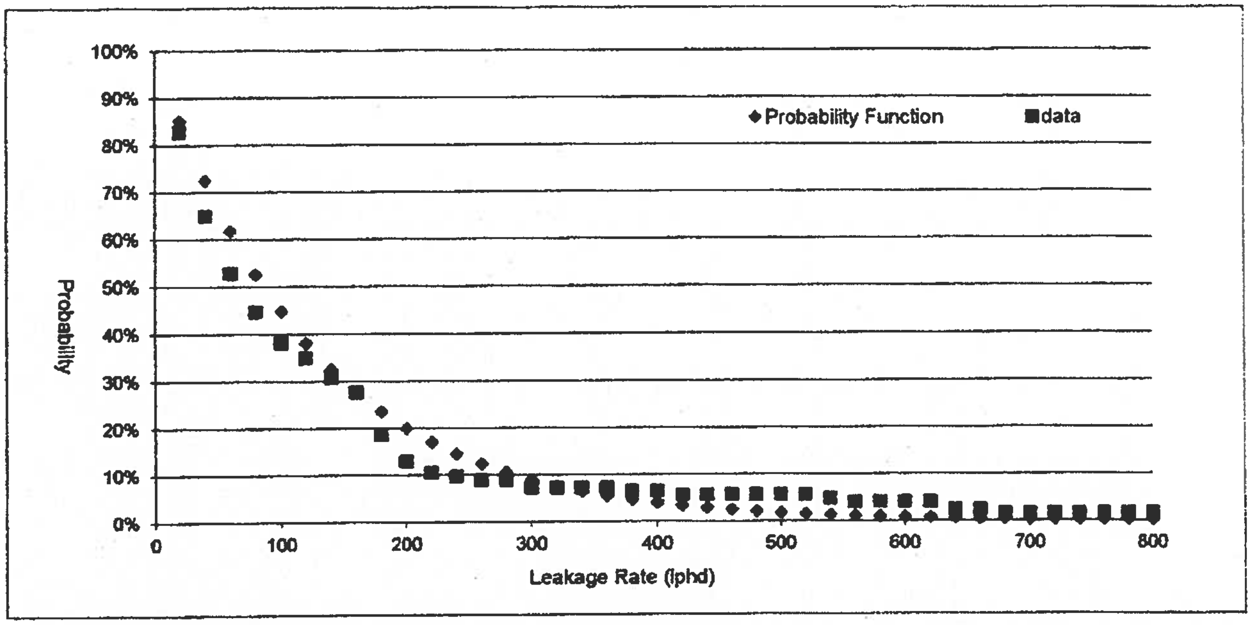

Figure 3: Probability of Exceeding Given Leakage Rate without survey. Probability function plotted along with observed data for double-lined landfills in New York State for reporting year 2010; data set from 122 discrete landfill cells, where no ELL survey was reported.

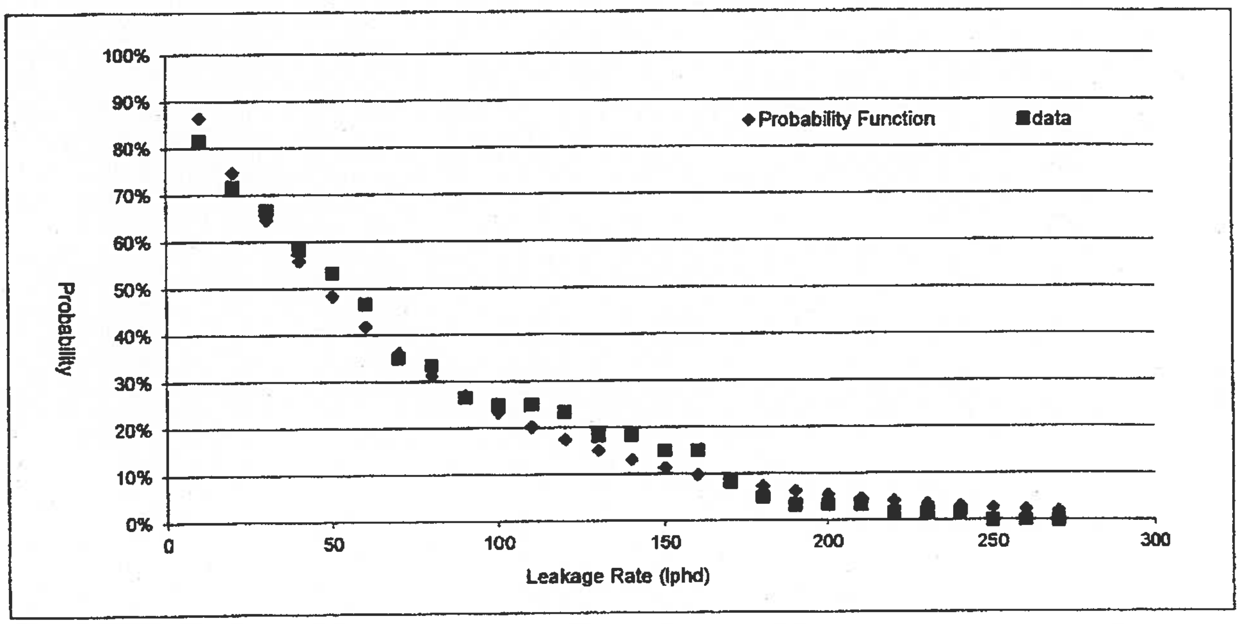

Figure 4: Probability of Exceeding Given Leakage Rate with dipole ELL survey. Probability function plotted along with actual leakage rates observed for double-lined landfills in New York State for reporting years 2006 - 2012; data set from 60 discrete landfill cells, where dipole ELL survey was performed as part of construction.

No leakage data is currently publicly available for landfill cells that have performed a bare geomembrane survey method after geomembrane installation, and then performed a dipole survey after placement of the cover materials. Therefore, some assumptions need to be made. The first assumption is that the probability equation used to create Figures 3 and 4 will be valid for the leakage resulting from the application of the other technologies presented here. This equation requires only the estimated average leakage rate subsequent to applying each technology in order to calculate the probability of exceeding a given ALR. The second assumption is that the ELL methods applied are applied per ASTM standard practices. If an ELL is not performed correctly, it will not locate leaks.

In order to estimate the average leakage rate for a geomembrane subsequent to performing a bare geomembrane survey followed by a soil-covered dipole survey, informed assumptions must be made for the following; leak density and percent of geomembrane covered by wrinkles.

It is inaccurate to make a blanket statement about the typical number of leaks in an installed geomembrane based on published leak statistics, since most of the published studies are now outdated and do not state the complete context of where the statistics came from such as country where the data was taken, whether the construction was new or the survey was on an existing (old) facility, and what ELL method was used to create the statistics. Leak densities can range from zero for new construction with excellent CQA to 75 or more leaks per hectare for older containment facilities or geomembrane construction outside of the U.S. The number of leaks in a given installation will be a function of the skill of the liner installer and the quality of the CQA effort, among other factors including weather that are difficult to predict. An average leak density located in newly constructed geomembrane containment systems in North America when CQA is used as part of construction is approximately 1.2 leaks per ha (0.5 leaks per acre), based on data collected by the author from 46 newly constructed geomembrane-lined containment facilities in North America, which implemented CQA as part of construction, from 2004 through 2010. There are likely more leaks that are not found due to poor contact conditions, so a range of 1.2 to 4.9 leaks per ha (0.5 to 2 holes per acre) was used for the analysis.

The extent of wrinkling can be expressed as a percentage of the total geomembrane area. Rowe provides estimations of wrinkle area as a function of time of day due to fluctuations of the geomembrane temperature (Rowe, 2012). In order to estimate the benefit that wrinkle reduction strategies can provide, the difference in temperature between a black geomembrane and a white geomembrane was analyzed. During the Spring, Summer, and Fall months, the maximum geomembrane temperature difference between a black and a white HDPE geomembrane varies from 25 to 43 °C (Koerner and Koerner, 1995). A temperature difference of 30°C corresponds to a difference in wrinkled area of at least 10% (Rowe, 2012). Therefore, one of the assumptions used for this analysis is that a geomembrane where no wrinkle management has been performed has a wrinkled area of 17%, while a reduced wrinkled area of only 7% can be achieved through moderate wrinkle management strategies. The probability of a hole landing on a wrinkle is assumed to equal the percentage of the area covered by a wrinkle, based upon the assumption that there is equal probability of a hole everywhere throughout the cell. In reality, a location such as the toe of the slope, which is more likely to contain a wrinkle, is also a location more likely to contain a leak, so this approach may underestimate the anticipated leakage.

The Rowe equation was used to calculate leakage resulting from a hole on a wrinkle, using the assumptions arrived upon in the case study described in Section 2.1. The leakage rate per hole on a wrinkle was calculated to be 25.9 lphd (6.85 gpad). The estimated leakage from a geomembrane after applying a bare geomembrane survey was then calculated by multiplying the area covered by wrinkles by the leakage rate per hole and the assumed number of holes per acre. This way, leakage is calculated for only the portion of the geomembrane containing wrinkles, which yields an overall average leakage rate if all of the leaks are located and repaired, except for the ones located within the wrinkled area.

If wrinkles can be completely eliminated, either actually or virtually, and a bare geomembrane survey is performed correctly, followed by a dipole survey after cover soil placement, there should not be any leaks in the geomembrane. Except for liquid generated by condensation or vapor diffusion, there should essentially be no leakage through the geomembrane.

Once the anticipated average leakage is calculated for each of the technologies discussed here, the probability of exceeding a given leakage rate can be calculated by using Equation [1].

3. RESULTS

The probabilities of exceeding typical landfill ALRs of 46.8 lphd (5 gpad) and 187.1 lphd (20 gpad) were calculated for each of the technologies discussed in the previous sections, both alone and in tandem. This was done by using the actual average leakage rate from the leakage data presented in Section 1.4 and when actual data was not available, the average leakage rate was estimated as described in Section 2.2. The results are presented below.

The probability of exceeding an ALR of 46.8 lphd (5 gpad) without applying any of the technologies discussed in this paper was calculated to be 68.7%. The probability of exceeding an ALR of 187.1 lphd (20 gpad) without applying any of the technologies discussed in this paper is calculated to be 22.2%.

The probability of exceeding an ALR of 46.8 lphd (5 gpad) after applying a dipole ELL survey only was calculated to be 50.7%. The probability of exceeding an ALR of 187.1 lphd (20 gpad) after applying a dipole ELL survey only was calculated to be 6.6%. If wrinkle reduction strategies are used, reducing the wrinkled area (and subsequently the average leakage rate) by 10%, the probabilities are decreased to 46.7% and 4.7% for an ALR of 46.8 lphd (5 gpad) and 187.1 lphd (20 gpad), respectively.

For enhanced quality control, a bare geomembrane survey should be performed after geomembrane installation, followed by a dipole survey after placement of the cover material. The probabilities of exceeding both ALRs after applying these measures are presented in Table 2 with three different leak densities and assuming a wrinkled area of 17% and 7% to represent no wrinkle management and moderate wrinkle management, respectively.

Table 2. Summary of Probabilities of exceeding ALR of 46.8 lphd (5 gpad) for both bare geomembrane survey and dipole survey performed and wrinkled area of 17% for leak densities of 1.2, 2.5 and 4.9 leaks per ha (0.5, 1 and 2 leaks per acre).

Leak Density (leaks per ha)	Estimated Leakage (lphd) [1]	Probability of Exceeding ALR
4.9	21.8	11.7%
2.5	10.9	1.37%
1.2	5.45	0.583%

[1] 1 lphd = 0.107 gpad

Table 3. Summary of Probabilities of exceeding ALR of 46.8 lphd (5 gpad) for both bare geomembrane survey and dipole survey performed and wrinkled area of 7% for leak densities of 1.2, 2.5 and 4.9 leaks per ha (0.5, 1 and 2 leaks per acre).

Leak Density (leaks per ha)	Estimated Leakage (gpad) [1]	Probability of Exceeding ALR
4.9	8.98	0.546%
2.5	4.49	2.98×10^{-3}%
1.2	2.24	8.88×10^{-8}%

[1] 1 lphd = 0.107 gpad

Table 4. Summary of Probabilities of exceeding ALR of 187.1 lphd (20 gpad) for both bare geomembrane survey and dipole survey performed and wrinkled area of 17% for leak densities of 1.2, 2.5 and 4.9 leaks per ha (0.5, 1 and 2 leaks per acre).

Leak Density (leaks per ha)	Estimated Leakage (gpad) [1]	Probability of Exceeding ALR
4.9	21.8	0.0187%
2.5	10.9	3.52×10^{-6}%
1.2	5.45	8.88×10^{-13}%

[1] 1 lphd = 0.107 gpad

Table 5. Summary of Probabilities of exceeding ALR of 187.1 lphd (20 gpad) for both bare geomembrane survey and dipole survey performed and wrinkled area of 7% for leak densities of 1.2, 2.5 and 4.9 leaks per ha (0.5, 1 and 2 leaks per acre).

Leak Density (leaks per ha)	Estimated Leakage (gpad) [1]	Probability of Exceeding ALR
4.9	8.98	8.88×10^{-10}%
2.5	4.49	7.89×10^{-19}%
1.2	2.24	6.23×10^{-37}%

[1] 1 lphd = 0.107 gpad

The probability of exceeding both ALRs is essentially zero if wrinkles can be eliminated in tandem with an exposed bare geomembrane survey followed by a dipole survey after cover soil placement (if applicable). This follows from the assumption that the ELL survey is performed per ASTM standard practices and is thus effective and that the wrinkle elimination strategies are effective. It has been reported for sites constructed using these specifications that leakage through the geomembrane is always attributed to faulty pipe penetrations and can be mitigated by a prefabricated pipe penetration design, which allows for spark testing the weld attaching the prefabricated pipe penetration to the geomembrane sheet. In a region of California where the regional water board prescribes double-lined ponds with zero leakage through the primary geomembrane, this is the approach taken, and has been successful.

4. CONCLUSIONS

More accurate methods of calculating anticipated average leakage rates are presented herein, along with a method of applying a probability analysis of exceeding a given ALR with the application of the technologies presented, both alone and in tandem. The tools presented here inform landfill designers, regulators and site owners of the appropriate technologies for the desired level of contaminant containment. These tools can assist design engineers to provide more realistic estimations of landfill leakage in order to adequately assess the potential impact of a proposed landfill expansion on an underlying aquifer. The cost of groundwater remediation and litigation resulting from groundwater contamination far exceeds the cost of minimal forethought and the application of the technologies presented here by many orders of magnitude.

If a site is required to comply with an ALR of 46.8 lphd (5 gpad), it is advisable to employ wrinkle reduction strategies, in tandem with performing both a bare geomembrane survey and a dipole survey after placement of the cover soil. With the application of these technologies, there is less than a 1.0% probability of exceeding the ALR, even in the presence of sub-optimum CQA where the leak density is on the high end of what is typically found for landfills in North America.

If a site is required to comply with an ALR of 187.1 lphd (20 gpad), it is advisable to specify both a bare geomembrane survey and a dipole survey after placement of the cover soil. With these measures, there is less than a 0.1% probability of exceeding the ALR. If only a dipole survey is specified, it is more likely than not that a landfill cell will exceed an ALR of 5 gpad, while the probability of exceeding an ALR of 187.1 lphd (20 gpad) can be as high as 6.6%. This probability is certainly higher if a site is only allowed a weekly averaging of leakage data.

The most conservative approach to minimizing leakage would be the complete elimination of wrinkles, either actually or virtually, and specifying both a bare geomembrane survey during construction and a dipole survey after the cover soil placement. This approach is recommended for any sites requiring a leakage rate of less than 5 gpad. This represents the most technologically feasible way of approaching the goal of zero leakage. This goal is now attainable with the technologies and services available for modern geomembrane construction.

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