BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:

PETITION OF MIDWEST GENERATION
FOR AN ADJUSTED
STANDARD FROM 35 ILL. ADM. CODE
PARTS 811 and 814

(Adjusted Standard-RCRA)

NOTICE OF FILING

To: Pollution Control Board, Attn: Clerk
100 West Randolph Street
James R. Thompson Center, Suite 11-500
Chicago, IL 60601-3218

Division of Legal Counsel
Illinois Environmental Protection Agency
1021 N. Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Pollution Control Board the attached Petition of Midwest Generation, LLC for Adjusted Standard from under 35 Ill. Adm. Code 811 and 814, the Appearances of Kristen L. Gale and Susan M. Franzetti, and a Certificate of Service, a copy of which is herewith served upon you.

Kristen L. Gale

Date: Feb 5, 2019

Kristen L. Gale
Susan M. Franzetti
Nijman Franzetti LLP
10 S. LaSalle Street, Suite 3600
Chicago, Il 60603
312 251 5255

CERTIFICATE OF SERVICE

I, the undersigned, certify that I have served the attached Petition for Adjusted Standard, and the Appearances of Kristen L. Gale and Susan M. Franzetti, by electronically filing with the Clerk and by first class mail upon IEPA:

Pollution Control Board, Attn: Clerk
100 West Randolph Street
James R. Thompson Center, Suite 11-500
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(Adjusted Standard-RCRA)

APPEARANCE

The undersigned, as one of its attorneys, hereby enters her appearance on behalf of Midwest Generation, LLC.

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(Adjusted Standard-RCRA)

APPEARANCE

The undersigned, as one of its attorneys, hereby enters her appearance on behalf of Midwest Generation, LLC.

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BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:

PETITION OF MIDWEST GENERATION FOR AN ADJUSTED STANDARD FROM 35 ILL. ADM. CODE PARTS 811 and 814	**AS 19-** **(Adjusted Standard-RCRA)**

MIDWEST GENERATION, LLC'S ADJUSTED STANDARD PETITION

Midwest Generation, LLC ("MWGen"), by its undersigned counsel, requests a revision to its existing adjusted standard ("AS 96-9"), attached as Exhibit 1, for the Joliet/Lincoln Quarry Site ("Quarry" or the "Site"). The requested revision applies only to Condition 7(c) of AS 96-9.[1]

In 1996, the Board granted an adjusted standard for the Quarry from the generally applicable standards due to its unique operations and disposal practices. Currently, Condition 7 of AS 96-9 describes two methods of final cover and the type of final cover depending on the level of settled ash at the time of the closure of the Main Quarry.[2] MWGen is preparing for the eventual closure of the Main Quarry and there is new technology available for a dry closure final cover. Accordingly, MWGen requests that the Board issue a new adjusted standard that revises Condition 7(c) to allow the use of this new technology if MWGen closes the Quarry through dry closure The new technology, known by the commercial name "ClosureTurf", employs a low permeability geosynthetic membrane and a synthetic turf as the final cover system. The proposed revised Condition 7(c) does not alter the previous substance or findings of the Pollution Control Board

[1] On December 7, 2000, the Board granted Commonwealth Edison's and MWGen's motion to reopen this docket and substituted the name of Midwest Generation, L.L.C. for Commonwealth Edison Company in its August 15, 1996 order. *In re Petition of Commonwealth Edison Company for an Adjusted Standard from 35 Ill. Adm. Code Parts 811 and 814*, AS 96-9, (December 7, 2000).

[2] The Quarry is comprised of three units: the Main Quarry, the North Quarry, and the West Filled Area. (Ex. 1, Order, p. 2). The West Fill Area at the Quarry is closed and has been leveled and vegetated. *Id*. The North Main Quarry does not receive ash, and instead acts as the settling pond for the Main Quarry. *Id.* In this Petition, MWGen is requesting authorization for the use of ClosureTurf only for the Main Quarry.

("Board"), is supported by the Board's opinion in *In re* Petition of Commonwealth Edison Company for an Adjusted Standard from 35 Ill. Adm. Code Parts 811 and 814, (Aug. 15, 1996), AS 96-9, and gives MWGen the ability to use an alternative and better final cover system for the dry closure of the Quarry. (Ex. 1). All of the remaining terms and conditions of AS 96-9 would remain unchanged.

This Petition sets forth the factual and legal bases for MWGen's request. In further support of this Petition, MWGen submits affidavits of Richard Gnat (KPRG and Associates, Inc.) and William Naglosky (Midwest Generation, LLC), attached as Exhibits 2 and 3 respectively. Additionally, Mr. Gnat has directed and participated in the preparation of the Technical Memorandum in Support of this Petition ("Technical Memorandum"), attached as Exhibit 4. The Technical Memorandum explains in greater detail the specific technical benefits of the "ClosureTurf" technology, and also describes its use at other landfills throughout the United States, including an Illinois impoundment.

I. Summary

On Aug. 15, 1996, the Board granted the prior owner of the Quarry an adjusted standard from certain of the operating and closure requirements of 35 Ill. Adm. Code 811 and 814 due to the unique nature of the Quarry ("Adjusted Standard" or "Order" attached here as Exhibit 1). Condition 7 of the Adjusted Standard provided for two methods for the Main Quarry's closure. The two methods were either wet closure for which no final cover was required or, dry closure by installation a two-stage cover system consisting of two feet of soil having a hydraulic conductivity of 1 x 10^{-7} cm/sec overlain by four inches of top soil. (Ex. 1, Order, Condition 7, pp. 22-23).

In 2015, the U.S.EPA promulgated the Coal Combustion Residual ("CCR") Rules, 40 CFR 257. Under the CCR rule, as it is currently drafted, all CCR impoundments are to be closed via dry closure.[3] Because the Main Quarry is a "CCR Impoundment" as defined in the Federal CCR rules, the Main Quarry may be closed via dry closure with a two-stage cover system. To address the eventual closure of the Main Quarry, MWGen considered technologies for final cover systems that were not available when the Board approved Condition 7(c) in AS 96-9. MWGen identified a new final cover two-stage system called "ClosureTurf". ClosureTurf is a new proprietary cover system, that is better technology than what was available in 1996. It also fully complies with the performance criteria of the Final Cover requirements under 35 Ill. Adm. Code 811.314. ClosureTurf has been used in at least seventeen states as a final cover system for impoundment and landfills, including a CCR surface impoundment in Meredosia, IL (Ex. 4, Technical Memorandum, at p. 1). As required by 35 Ill. Adm. Code 811.314(b)(3)(B)(i), the ClosureTurf system has a low permeability layer of geomembrane that has a permeability of 1 x 10^{-13} cm/sec, which is less permeable than the regulatory requirement of 1 X 10^{-7} under 35 Ill. Adm. Code 811.314(b)(3)(A). Section 811.314(c) of the landfill final cover regulations provides for a final protective layer that consists of 3 feet of soil, which overlays the underlying low permeability layer. The ClosureTurf system includes a final protective layer that is not soil. It consists of synthetic turf and sand, which provides equal protection of the underlying low permeability layer,

[3] The CCR rule is the subject of litigation filed in the D.C. Circuit, and the Court has already vacated parts of the CCR Rule. *Utility Solid Waste Activities Group (USWAG) et al. v. EPA*, No. 15-1219 (D.C. Cir.). In part in response to the litigation, in March 2018, U.S.EPA proposed more than a dozen changes to the 2015 CCR Rules. On July 17, 2018, the U.S.EPA Administrator signed a final rule revising certain elements of the CCR Rule, based on the changes proposed in March 2018. 83 FR 36435. The July 2018 changes are referred to as the "Phase 1, Part 1 Rule." The elements that were not contained in the final Phase 1, Part 1 Rule will be addressed in the final Phase 1, Part 2 Rule. According to the Phase 1, Part 1 Rule preamble, the U.S.EPA intends to finalize the Phase 1, Part 2 Rule by June 2019. 83 FR 36437. Additionally, U.S.EPA will propose the "Phase 2" changes to the CCR rule, by September 20, 2019, and finalize the Phase 2 changes by December 2019. Accordingly, the 2015 CCR rules and amended 2018 rules will have significant changes, including to its timelines and potentially also to the final closure requirements.

while also providing protection from erosion and freezing, as required by 35 Ill. Adm. Code 811.314(c). Accordingly, MWGen requests that the Board revise Condition 7(c) to provide that, if MWGen pursues dry closure, MWGen may close the Main Quarry using the ClosureTurf two-stage system, which has a low permeability layer compliant with 35 Ill. Adm. Code 811.314(b), and has a final protective layer that is different from, but meets or exceeds the performance requirements of, the soil cover material in 35 Ill. Adm. Code 811.314(c) and AS 96-9.

II. Background

On Aug. 15, 1996, the Board granted an adjusted standard from 35 Ill. Adm. Code 814.302(b)(1), 811.319(a)(2), 811.319(a)(3), 811.318(b)(5), 811.320(c), and 811.314. (Ex. 1, Order). The Board found that the Quarry configuration, including the differences in the flow regime, mode of operations, and waste characteristics were substantially different from the factors the Board relied on in adopting the general regulations for municipal landfills. *Id*. MWGen is not requesting that the entire adjusted standard granted in 1996 be revisited and revised. Rather, MWGen is only requesting that the Board modify Condition 7(c) to allow the use of improved final cover technology that is currently available..

A. The Board's AS 96-9 Findings and Conclusions Regarding the Main Quarry are Still Applicable.

The analysis and conclusions in the AS 96-9 order for the adjusted standard from the generally applicable landfill regulations continue to apply today. Since 1996, the Quarry has only accepted bottom ash for disposal, and until the MWGen Stations at Joliet were converted to natural gas in 2016, the Quarry has operated the same as it operated when the Board issued its AS 96-9 Final Order. Because neither the operations nor materials disposed have changed, there is no basis or need to modify the other provisions of AS 96-9.

In particular, in 1996, the Board found that it was impractical to require a system to drain and collect leachate required by 35 Ill. Adm. Code 814.302(b)(1) based upon the unique configuration of the Quarry. (Ex. 1, Order, p. 6).[4] The configuration of the Quarry is the same today. Water in the Quarry continues to flow through the gravity-flow drainage system, and the water ultimately is discharged pursuant to the Quarry's NPDES permit. (Ex. 2 at ¶4).

Similarly, unlike municipal solid waste landfills, in 1996 the Quarry accepted only bottom ash and slag from the Joliet electric generating Stations 9 and 29. The Board found that "given the absence of organic chemicals and consistency of constituents for almost 20 years" in the Quarry, the concerns underlying the monitoring requirements in the landfill regulations were not present, and an adjusted standard from 35 Ill. Adm. Code 811.319(a)(2)[5] and 811.319(a)(3)[6] was warranted. (Ex. 1, Order, at p. 9). The Board's conclusions equally apply today. From 1996 to the present, only bottom ash and slag were placed in the Quarry and the constituents in the ash remained the same. (Ex. 3 at ¶6). Since the gas conversion in 2016, only bottom ash from the cleanout associated with the conversion and the closure of residual ash ponds from Joliet 29 Station north of the river has been placed in the Quarry. Once the Joliet 29 ash ponds are empty, no additional ash or any waste material will be placed in the Quarry. (Ex. 3 at ¶7).

[4] The language in 35 Ill. Adm. Code 814.302(b)(1) has not changed since the original Petition for Adjusted Standard was filed in 1996.

[5] The language in 35 Ill. Adm. Code 811.319(a)(2) has not significantly changed since the original Petition for Adjusted Standard was filed in 1996, other than Section 811.319(a)(2)(ii), which was modified to include a minimum list of constituents for municipal solid waste landfills and a requirement that a facility that does not accept primarily municipal waste determine additional factors. As MWGen analyzes the groundwater samples for the constituents from coal ash, these modifications to Section 811.319 do not change the conclusion that the approved adjusted standard for groundwater monitoring continues to be applicable.

[6] The language in 35 Ill. Adm. Code 811.319(a)(3) has not significantly changed since the original Petition for Adjusted Standard was filed in 1996, other than Section 811.319(a)(3)(A), which was modified to include a list of organic chemicals. Because coal ash disposed in the Main Quarry does not contain organic chemicals, this modification to Section 811.319(a)(3)(A) does not change the conclusion that the approved adjusted standard for groundwater monitoring continues to be applicable.

In 1996, the Board also concluded that an alternative groundwater monitoring network was required because the groundwater flow regime at the Quarry was not the type considered by the Board when adopting 35 Ill. Adm. Code 811.318(b)(3).[7] The groundwater flow regime at the Quarry is unchanged.[8] (Ex. 2, ¶4). The natural groundwater flows from the south to the north and east to west and the groundwater elevation of the surrounding area is higher than the base of the Quarry. (Ex. 2, ¶5). Since 1996, MWGen has installed additional monitoring wells and conducted detailed groundwater monitoring that "establish a network of groundwater monitoring wells that protects the environment and which comprehensively and accurately depicts constituent migration at the Site." (Ex. 1, Order, at p. 11, citing 1996 Petition, at p. 72 (attached as Exhibit 5)).[9] As a result, the current groundwater monitoring network is more expansive and comprehensive than that originally approved by the Board. (Ex. 2, ¶¶6-7).

The Board also granted an adjusted standard for 35 Ill. Adm. Code 811.320(c)[10] and granted a broader zone of attenuation as part of an agreement with the Illinois Environmental Protection Agency ("Illinois EPA") to establish a groundwater management zone ("GMZ"). The GMZ was established as part of the remediation solution due to historic disposal of ash in the West Filled area at the Quarry. (Ex. 1, Order, p. 13). The Board concluded that an adjusted zone of attenuation was justified due to the chemistry of the Quarry, the local nature of the groundwater flow system, and because the future use of the groundwater will be controlled, preventing adverse

[7] The language in 35 Ill. Adm. Code 811.318(b)(3) has not changed since the original Petition for Adjusted Standard was filed in 1996.

[8] Today, due to the operations of the Vulcan Quarry, there is a southerly component in the groundwater flow. In response to the Vulcan Quarry operations, MWGen has installed a groundwater extraction system. The groundwater extraction system is unrelated to the Final Cover system that is the subject of this Petition. (Ex. 2, ¶6).

[9] In Illinois EPA's Response to the 1996 Petition is attached for reference as Exhibit 6. Illinois EPA recommended that the requested adjusted standard be granted. (Ex. 6, p. 5).

[10] The language in 35 Ill. Adm. Code 811.320(c) has not changed since the original Petition for Adjusted Standard was filed in 1996.

environmental or health effects. (Ex. 1, Order, p. 14). The Board's conclusions continue to apply today. The groundwater monitoring and modeling at the Quarry show that the concentrations in the groundwater from the Main Quarry do not negatively affect Des Plaines River water quality. (Ex. 2, ¶8). Additionally, as in 1996, MWGen continues to control the future use of the groundwater, preventing adverse environmental or health effects. (Ex. 2, ¶10).

B. The Final Cover Approved by AS 96-9 Can Be Improved Based on Current Technology.

In 1996, the Board also granted an adjusted standard for the final cover of the Main Quarry. Because the water infiltration through percolation was relatively small compared to the groundwater infiltration into the waste area, the Board found there was no environmental benefit to installing a cover pursuant to Section 811.314. (Ex. 1, Order, p. 17). Additionally, because the conditions under which the Main Quarry would be closed were unknown in 1996 (*i.e.*, either closure below the water table or above the water table), the Board granted two alternative cover systems for the Main Quarry (Conditions 7(b) and 7(c)). (Ex. 1, Order, p. 17, 22-23). If the Main Quarry were to be closed above the water table (a/k/a "dry closure"), AS 96-9 provided that the cover would be a 2-foot layer of compacted soil having a hydraulic conductivity of $1x10^{-7}$ cm/sec., overlain by at least four inches of topsoil. (Ex. 1, Order, p. 23).

If MWGen pursues dry closure of the Main Quarry, MWGen prefers to use the ClosureTurf two-stage cover system because it is superior technology to what was available in 1996. (Ex. 2, ¶11). The ClosureTurf cover has a low permeability geomembrane layer that meets the requirements of the final cover requirements in 35 Ill. Adm. Code 811.314(b). (Ex. 2, ¶¶, 11, 13) Additionally, the ClosureTurf cover has a final protective layer that is different from, but meets or exceeds the performance of, the final protective cover provided for in 35 Ill. Adm. Code 811.314(c) and allowed in the Adjusted Standard. (Ex. 2, ¶12) As described in detail below, the final protective layer is comprised of a synthetic turf layer with a 0.5-inch sand infill, which effectively prevents erosion and reduces the maintenance requirements that are associated with a vegetative layer. *See* Sec. (g) and (h), (Ex. 2, ¶12). Accordingly, MWGen requests that the Board revise Condition 7(c) to provide that MWGen may use the ClosureTurf two-stage cover system if it pursues dry closure.

C. The Board has the Authority to Issue a New Adjusted Standard with Only One Condition Modification.

The Board has previously issued a new adjusted standard to modify one specific part of the previously approved adjusted standard. In *In the Matter of: Petition of Metropolitan Water Reclamation District of Greater Chicago for an Adjusted Standard from 35 Ill. Adm. Code 811, 812 and 817 and Modification of AS 95-4*, the Metropolitan Water Reclamation District ("MWRD") requested that the Board modify AS 95-4, which the Board had previously approved. (MWRD's Petition For An Adjusted Standard, *In the Matter of: Petition of Metropolitan Water Reclamation District of Greater Chicago for an Adjusted Standard from 35 Ill. Adm. Code 811, 812 and 817 and Modification of AS 95-4*, AS 03-02, p. 1 (Feb. 11, 2003), attached as Exhibit 7, attachments excluded). In the first adjusted standard, AS 95-4, the Board granted MWRD's petition to use MWRD dried sludge material at non-hazardous waste landfills in lieu of soil material for the top protective layer for final cover. (Ex. 7, p. 2). In MWRD's request for modification, MWRD asked the Board to modify the temperature and detention time requirements for the processed sludge enumerated in Condition 3.a of its adjusted standard. (Ex. 7, p. 2, 13). In particular, MWRD requested the revision because the original adjusted standard, AS 95-4, did not consider the temperature fluctuations that occurred periodically during the processing of the sludge, and that were accepted by the U.S.EPA in the federal Sewer Sludge regulations. (Ex. 7, p.

7). In its petition for revision, MWRD referenced its prior petition, incorporated by reference the sections and information contained in the petition, and only addressed the specific issue it was requesting be modified. (Ex. 7, pp. 9-12).

The Board granted MWRD's request and issued a new adjusted standard in which the Board retained all but one of the existing adjusted standard conditions. As requested by the MWRD, the Board modified one condition to reflect the updated temperature and detention time requirements. *See* Board Order, *In the Matter of: Petition of Metropolitan Water Reclamation District of Greater Chicago for an Adjusted Standard from 35 Ill. Adm. Code 811, 812 and 817 and Modification of AS 95-4*, AS 03-02, p. 7, 11-12 (July 24, 2003), attached as Exhibit 8.[11] With the exception of the one modified condition, the new adjusted standard, AS 03-02, included all the other conditions as originally stated in the original adjusted standard. *Id.*

III. Analysis and Petition Content Requirements

The Board requires that certain information be included in each petition for an adjusted standard. 35 Ill. Adm. Code §104.406. In this case, however, MWGen seeks only a revision to one part of a condition of its existing adjusted standard. The informational requirements for the previously approved conditions in the existing adjusted standard still apply as well as the basis for approving the adjusted standard. Accordingly, MWGen is addressing the informational requirements in 104.406 as they relate to its request to modify Condition 7(c) of AS 96-9.

a) Standard from which Adjusted Standard is Sought. The rule-of-general applicability for which MWGen requests an adjusted standard is at 35 Ill. Adm. Code 811.314. MWGen requests that Condition 7(c) of its AS-96-9 be revised as described herein.

[11] MWRD noted, and the Board, agreed that the Board's rules do not provide a method for amending an adjusted standard. *Id.* at 7. Thus, the Board granted a new adjusted standard. *Id.*

b) <u>Whether the regulation was promulgated to implement … RCRA…</u>. The 811.314 regulation was promulgated to implement the State program concerning RCRA.

c) <u>Level of Justification as Specified by the Regulation</u>. Section 811.314 does not include a specific justification for an adjusted standard.[12]

d) <u>Nature of Petitioner's Activity that is the Subject of the Proposed Adjusted Standard</u>. The Main Quarry is approximately 43 acres in size and is located south of the Des Plaines River at the corner of Brandon Road and Patterson Road in unincorporated Will County, south of Joliet, Illinois. (Ex. 2, ¶15, Ex. 3, ¶3). MWGen has used the Main Quarry site for the disposal of CCR from the Joliet 9 and Joliet 29 Generating Stations. The two stations employ 47 people. (Ex. 3, ¶4). As described in the Board's 1996 Order, the Main Quarry has been used to receive bottom ash since about 1975. (Ex. 1, Order, p. 2). When the generating stations were fueled by coal, the Main Quarry operated as a landfill to manage the sluice water and CCR from the stations. (Ex. 1, Order, p. 2).

The currently applicable closure method at the Main Quarry is Condition 7 in the 1996 Adjusted Standard AS-96-9, which is adjusted from the generally applicable rule 35 Ill. Adm. Code 811.314. (Ex. 1, Order, Condition 7). The Adjusted Standard allows for either wet closure or dry closure. *Id.* If dry closure is selected, the Adjusted Standard requires a two-stage final cover system, consistent with 35 Ill. Adm. Code 811.314. *Id.* The Adjusted Standard requires a two-feet thick low permeability layer with a hydraulic conductivity of 1×10^{-7} cm/sec, and a final protective layer of 4-inches of topsoil. *Id.*

[12] Section 811.314(c) describes alternative requirements for an infiltration barrier for an owner of an municipal solid waste landfill ("MSWLF") that disposes of less than 20 tons of waste, which does not apply to the Quarry.

Since the Adjusted Standard was granted, new technology is available for a final cover system referred to as a "ClosureTurf" final cover system. ClosureTurf is a relatively new proprietary cover system (not available at the time of the initial Adjusted Standard), which consists of a geomembrane low permeability layer covered with synthetic turf and sand in place of a soil protective layer. (Ex. 2, ¶¶11-13). The ClosureTurf cover system will cover the Main Quarry area of approximately 43 acres and tie into the east slope of the West Fill Area, within the property limits of the Quarry, for a total final cover surface area of approximately 47 acres. (Ex. 2, ¶15). Upon installation, the design of the ClosureTurf system would allow stormwater to pass through the synthetic turf and sand infill, and onto the surface of the geomembrane. (Ex. 2, ¶14) Stormwater would then flow to the drainage system of the North Quarry, and ultimately discharged pursuant to the Quarry's NPDES permit. *Id*.

Since the conversion of the Joliet Stations to natural gas in 2016, only groundwater flow has "discharged" into the Quarry. In 1996, the influx of groundwater into the Main Quarry was conservatively estimated at 664,400 gallons per day ("gpd"). (Ex. 5, pp. 30-31). Additionally, in 1996, approximately 76% of the conservatively estimated total groundwater flow (approximately 505,000 gpd) that entered the Main Quarry discharged through the gravity flow system into the North Main Quarry and reached the Des Plaines River through the North Main Quarry pumping system under NPDES Permit No. IL0002216. *Id*. The remaining 24% (approximately 159,400 gpd) of the groundwater discharged directly to the Des Plaines River. *Id*. The drainage, pumping and discharge system in the Main Quarry operates the same way today as it did in 1996, thus the estimated percentage of groundwater that drains into the North Quarry and Des Plaines River is unchanged. (Ex. 2, ¶9). In 2013, MWGen had groundwater modeling conducted as part of the revised Groundwater Impact Assessment submitted and approved to the Illinois EPA. *Id*. The groundwater modeling estimated that the volume of groundwater that discharges into the Main Quarry had decreased to approximately 542,900 gpd. *Id*. Accordingly, of the groundwater that enters the Main Quarry, 412,600 gpd to 505,000 gpd (*i.e.*, 76% of the total volume) is discharged through the gravity flow system into the North Main Quarry, and the remaining groundwater flow, 130,300 gpd to 159,400 gpd, discharges to the Des Plaines River. *Id*.

The original 1996 petition contains a detailed description of the pollution control equipment currently used at the Quarry, and that will be in use upon closure. (Ex. 5). There is no pollution control equipment currently associated with the final cover of the Main Quarry because the Quarry is not yet closed.

e) Efforts to Comply with Regulation. Closing the Main Quarry in accordance with section 811.314, requires a two-part final cover system consisting of a low permeability layer and a final protective layer. Compliance with the generally applicable regulation for the final cover system as opposed to the proposed ClosureTurf two-part system, entails significantly higher costs with no added environmental benefits. It would consist of a 3-feet thick low permeability soil layer and a 3 feet thick final protective layer of soil spread over 47 acres. 35 Ill. Adm. Code § 811.314(b)(3)(A). The two-part final cover would require 250,250 cubic yards ("CY") of clay, and an additional 250,250 CY of soil for the final protective layer. (Ex. 2, ¶18). MWGen does not have an onsite borrow source, accordingly the soils for both layers would have to be purchased and brought on site from an offsite source. (Ex. 2, ¶19). Bringing a total quantity of 500,500 CY of soils to the site would require 33,367 trucks based on a 15 CY per truck capacity. (Ex. 2, ¶20). The total cost for purchase and transport of the soil quantities required for the soil layers would be approximately $13,000,000. *Id*.

Under the generally applicable regulation, the other final cover design alternative is a geomembrane layer that meets or exceeds the performance capabilities of the soil low permeability layer which is covered by a vegetation-supporting three-feet thick soil protective layer. 35 Ill. Adm. Code 811.314(b)(3)(B). The total construction cost of a geomembrane low permeability layer and a three-foot soil protective layer (approx. 250,250 CY) is approximately $10,300,000. (Ex. 2, ¶21).

The Adjusted Standard, AS 96-9, instead allows a 2-foot low permeability layer and a 4-inch protective layer, (Ex. 1, p. 23), which would require approximately 167,000 CY of clay, and an additional 28,000 CY of soil for the final protective layer. (Ex. 2, ¶22). The total approximate cost for the Adjusted Standard final cover would be approximately $6,100,000. (Ex. 2, ¶23).

The Adjusted Standard post-closure requirements for the final cover are the same as for a generally applicable final cover. For all of the approved final covers, the post-closure requirements include mowing of the grass on the cover, annual inspections, and conducting any necessary repairs to the vegetative cover or the drainage channels. (Ex. 2 ,¶24). The annual cost for post-closure care is approximately $277,000. The total post-closure care cost for thirty years of post-closure activities is $8,310,000. (Ex. 2 ,¶25)

A fourth alternative is removing all CCR from the Main Quarry and disposing it in a licensed offsite landfill. Complete removal of all the CCR would require the removal and offsite disposal of an estimated 2,600,000 CY of ash material. (Ex. 2, ¶26). The cost for excavation of the CCR is estimated at $38,400,000 based on the original 1994 cost updated to 2018 costs. (Ex. 2, ¶27). Disposal of all the CCR from the Main Quarry would cost in excess of $230,000,000 based on updating the original 1994 cost to 2018 costs and would require approximately 149,700 truckloads to remove it to an off-site landfill. (Ex. 2, ¶28). Accordingly, the total cost for removal and disposal of the CCR is $268,400,000.

f) Proposed Adjusted Standard. MWGen's requested revision changes the language in Condition 7(c) of AS96-9 to allow MWGen to use the improved final closure two-stage system, ClosureTurf, which uses a geomembrane as a low permeability layer and meets the specific requirements in 35 Ill. Adm. Code 811.314(b). The ClosureTurf system also uses a protective layer system that works as effectively as soil material to protect the geomembrane from freezing and UV exposure. This protective layer system also eliminates the risk of erosion caused by wind and stormwater.

MWGen proposes that Condition 7(c) be revised as follows:

Redlined Proposed Changes:

7) Final Cover.

a) For purposes of b) and c) below, "maximum adjusted seasonal water table level" means the maximum predicted water table level in the vicinity of the Joliet/Lincoln Quarry Site, determined at the time of closure, plus sufficient elevation to ensure the integrity of a cap.

b) Closure Below Water Table.

i) If, at the time of closure, the level of settled ash in Lincoln Quarry is at or below the maximum adjusted seasonal water table level, no final cover is required for the Quarry and the Quarry shall be maintained as an impoundment.

ii) Water levels in the Quarry shall be maintained at or below a maximum elevation of 570 feet above sea level.

iii) A chain link fence no less than eight (8) feet in height, topped by a no less than three (3) strands of barbed wire, shall be installed around the Joliet/Lincoln Quarry Site to prevent access and shall be maintained in good condition at all times.

c) Closure Above Water Table.

i) If, at the time of closure, the level of settled ash in Lincoln Quarry is above the maximum adjusted seasonal water table level, ~~Edison~~ MWGen shall install "ClosureTurf", a two-stage cover system which shall consist of a geomembrane layer that has a hydraulic conductivity of at least 1 x 10-7 cm/sec, overlain with a cap of synthetic turf infilled with 0.5 inches of sand. ~~a two-stage cover system, which shall consist of a compacted clay layer that performs equivalently to a 2 foot layer of compacted soil having a hydraulic conductivity of 1 x 10^{-7} cm/sec, overlain by at least four inches of topsoil.~~ The cap shall be graded to maintain a positive grade from the perimeter of the Main Quarry walls to the discharge pipes. ~~at no less than 2% grade and shall drain to a collection area located on the cap~~. Stormwater collecting on the cap shall gravity drain through the discharge pipes to the North Quarry for settling prior to discharge pursuant to the facility's NPDES permit. ~~be pumped to the North Quarry for settling prior to discharge pursuant to the facility's NPDES permit. The cap shall be seeded to prevent erosion.~~

ii) Water levels in the Main Quarry shall be maintained through use of an underdrain collection system located below the geomembrane layer of the cover system located at the discharge pipes. Groundwater shall drain by gravity to the North Quarry for settling prior to discharge pursuant to the facility's NPDES permit. ~~at no more than 570 feet above sea level through use of a gravel drainage blanket underlying the stormwater collection area. Water collecting in the drainage blanket shall drain by gravity to the North Quarry for settling prior to discharge pursuant to the facility's NPDES permit.~~

Clean Final Proposed Changes:

7) Final Cover.

a) For purposes of b) and c) below, "maximum adjusted seasonal water table level" means the maximum predicted water table level in the vicinity of the Joliet/Lincoln Quarry Site, determined at the time of closure, plus sufficient elevation to ensure the integrity of a cap.

b) Closure Below Water Table.

i) If, at the time of closure, the level of settled ash in Lincoln Quarry is at or below the maximum adjusted seasonal water table level, no final cover is required for the Quarry and the Quarry shall be maintained as an impoundment.

ii) Water levels in the Quarry shall be maintained at or below a maximum elevation of 570 feet above sea level.

iii) A chain link fence no less than eight (8) feet in height, topped by a no less than three (3) strands of barbed wire, shall be installed around the Joliet/Lincoln Quarry Site to prevent access and shall be maintained in good condition at all times.

c) Closure above Water Table.

i) If, at the time of closure, the level of settled ash in Lincoln Quarry is above the maximum adjusted seasonal water table level, MWGen shall install "ClosureTurf", a two-stage cover system which shall consist of a geomembrane layer that has a hydraulic conductivity of at least 1 x 10-7 cm/sec, overlain with a cap of synthetic turf infilled with 0.5 inches of sand. The cap shall be graded to maintain a positive grade from the perimeter of the Main Quarry walls to the discharge pipes. Stormwater collecting on the cap shall gravity drain through the discharge pipes to the North Quarry for settling prior to discharge pursuant to the facility's NPDES permit.

ii) Water levels in the Main Quarry shall be maintained through use of an underdrain collection system located below the geomembrane layer of the cover system located at the discharge pipes. Groundwater shall drain by gravity to the North Quarry for settling prior to discharge pursuant to the facility's NPDES permit.

The remaining Conditions to AS-96-9 are unchanged. This revision will allow MWGen to install a final cover more effective than the cover approved in Condition 7(c) in AS 96-9.

g) Description of Impact on the Environment of Complying with the Regulation vs. Complying with the Adjusted Standard.

Neither the generally applicable nor the existing Adjusted Standard cover systems requirements have a more favorable environmental impact compared to the ClosureTurf cover system proposed here.[13] Rather, the ClosureTurf two-stage cover system is better technology because it includes a low permeability geomembrane layer with a permeability of 1×10^{-13} cm/sec, which provides a higher degree of protection against seepage through the final cover

[13] In its decision on the original adjusted standard petition, the Board found that the generally applicable cover system had little or no favorable environmental impact when compared to the adjusted standard's two-feet thick compacted clay layer and four-inch protective layer for dry closure. (Ex. 1, Order, p. 17, Ex. 5, pp. 97-98)

than the permeability standard contained in 35 Ill. Adm. Code 811.314(b). (Ex. 2, ¶13; Ex. 4, Technical Memorandum, *See also* Sec. (h)). Additionally, the protective cover layer of the ClosureTurf system of turf and sand infill installed to protect the geomembrane layer is expected to provide better protection against erosion from stormwater runoff, wind speeds, and even vehicle traffic. (Ex. 2, ¶11-12, Ex. 4, *See also* Sec. (h)). Hence, there should be a lower potential for, and frequency of, needed maintenance or repairs to the final cover system.

Not only is the ClosureTurf system environmentally more beneficial than the generally applicable final cover, the installation process for the ClosureTurf will have less of an environmental impact. The environmental impacts of the generally applicable final cover installation include increased fugitive particulate emissions during soil delivery and the placement and grading of the soil layer. Delivery and installation of the ClosureTurf system, compared to the generally applicable regulation, is estimated to decrease total construction related carbon emissions and $PM_{2.5}$ emissions by 65%. (Ex. 2, ¶29).

h) <u>Justification of Proposed Adjusted Standard</u>. As described in detail by the Board in its Opinion and Order AS 96-9, the justification for the alternative cover is not necessarily affected by this request to revise a condition. (Ex. 1, Order, pp. 16-17). Instead, revision of Condition 7(c) will allow MWGen to use the ClosureTurf two-part cover system that is at least equivalent and in some ways superior to the Illinois landfill regulations, and more effective than the system approved in AS 96-9. Overall, the benefits of ClosureTurf include a reduction of installation and maintenance time, long-term maintenance efforts and costs, and environmental impacts associated with construction. (Ex. 2, ¶¶11-14). ClosureTurf was approved for use as final cover in 2017 for a CCR impoundment in Meredosia, IL closed by Ameren Energy and has also been used in approximately 17 other states. (Ex. 4, p. 1). The total estimated cost for installation of the ClosureTurf is approximately $8,900,000 (Ex. 2, ¶16).

Low Permeability Layer: The geomembrane used in the ClosureTurf cover system will achieve a permeability of $1x10^{-13}$ cm/s, which is less than the $1x10^{-7}$ cm/s required under 35 Ill. Adm. Code 811.314(b)(3). The permeability of the geomembrane was determined from research conducted by CTT Group. (Ex. 2, ¶13, Ex. 10). The geomembrane that will be used in the ClosureTurf system is substantially lower in permeability than the standard 1x10-7 cm/s design requirement, and will result in less potential precipitation infiltrations thereby exceeding design requirements. (Ex. 2, ¶13, Ex. 4). Accordingly, the geomembrane in the ClosureTurf system is in accordance with the requirements of 35 Ill. Adm. Code 811.314(b)(3).

Final Protective Layer: The ClosureTurf final protective layer consists of synthetic turf with sand infill that completely covers the geomembrane and prevents it from being exposed and degraded by UV radiation. (Ex. 2, ¶¶11-12). The synthetic turf and sand infill are specifically designed to stay in place during rain events and do not require vegetation to hold it in place. *Id.* Additionally, the synthetic turf and sand infill allow stormwater to pass through them onto the surface of the geomembrane, which is designed to transport stormwater to the drainage system to the North Quarry. (Ex. 2, ¶14). Because the purpose of the protective layer is to prevent the degradation of the low permeability layer to ensure its performance against infiltration into the waste being covered, the ClosureTurf protective layer will protect the geomembrane from desiccation, root penetration, and erosion. (Ex. 2, ¶12). The Geosynthetic Institute (“GSI”) published White Paper #28 (attached as Exhibit 9) reported that the tensile tests on the geomembrane “showed no change in the peak strength or peak elongation of any of the tested materials”, the shear tests on the geomembrane seams “showed no change in shear strength of any of the tested seam materials"; and the peel tests on the geomembrane seams "showed no change in peel strength of any of the tested seam materials" when exposed to freeze-thaw cycle. *Id.* at p. 7-8. The GSI White Paper further states there is simply 'no change' in tensile behavior of geomembrane sheets or their seams after freeze-thaw cycling. *Id*. The authors answer the question of whether freeze-thaw cycling will affect geomembranes and their seams with "a resounding NO." *Id.* at p. 10. In short, the freeze-thaw cycle the ClosureTurf system will experience in Joliet, Illinois will not negatively impact its performance.

Additionally, ClosureTurf eliminates the need for vegetation by using synthetic turf and sand infill to cover the geomembrane. The synthetic turf looks similar to natural grass and is available in green, tan, or a green/tan combination of colors to blend with the surrounding environment and create the appearance of grass. (Ex. 2, ¶11). The synthetic turf is specifically designed to grab and hold the sand infill to prevent its migration during rain and wind events. *Id.* Third party testing has shown that the design of the synthetic turf is able to resist uplift pressure from winds as high as 120 miles per hour (mph). (Ex. 4, p. 2). This testing also showed that the sand infill did not migrate during the high wind speeds, but acted as a ballast for the synthetic turf during the high wind speeds. (Ex. 4, p. 5). The synthetic turf used in ClosureTurf is designed to prevent the migration of the sand infill and the sand infill particle size is chosen to work in concert with the synthetic turf design. (Ex. 4, p. 11-12). ClosureTurf was tested by a third party in accordance with ASTM 6459 using rainfall intensities correspond to about a 2-year, 24-hour storm; about a 25-year, 24-hour storm; and about a 100-year, 24-hour storm; respectively, based on the runoff conditions at LSQ. (Ex. 4, p. 12). Sand infill was not identified in the 2-year or 25-year storm runoff and only 0.41 lbs. of sand infill was identified in the 100-

year storm runoff. (Ex. 4, p. 12). ClosureTurf will adequately minimize the transport of any sand infill into the receiving water body, and minimize any erosion from the final protective layer.

The absence of a vegetative cover is a significant advantage of the ClosureTurf system. Post-closure care for ClosureTurf for the 30- year post-closure period is estimated to be approximately $5.1 million, which is significantly less than the cost of the estimated post-closure care for a generally applicable final cover. (Ex. 2, ¶17, 24).

Supplemental information regarding the effectiveness of the ClosureTurf, including its durability, longevity, accessibility, and other considerations are described in the Memorandum attached as Exhibit 4.

i) <u>Reasons the Board may Grant the Proposed Adjusted Standard</u>. The reasons for granting the adjusted standard are detailed in the Board's Opinion and Order at Att. A. (Ex. 1, Order). Amending Condition 7(c) of the Board's Order will not change the Board's findings or analysis, only adjust the type of two-state cover system that will be used. The Board may also grant this revision of Condition 7(c) of AS 96-9 because it is consistent with federal law, and there are no procedural requirements applicable to the Board's decision on the petition that are imposed by federal law and not required by the Board regulations. As described in Section II.C. above, the Board has previously issued a new Adjusted Standard in which it modified only one Condition based upon new information from a Petitioner. *In the Matter of: Petition of Metropolitan Water Reclamation District of Greater Chicago for an Adjusted Standard from 35 Ill. Adm. Code 811, 812 and 817 and Modification of AS 95-4*, AS 03-02, p. 1 (Feb. 11, 2003). (Ex. 8). For similar reasons that the Board granted the Metropolitan Water Reclamation District's petition, the Board may grant MWGen's petition here.

j) Hearing on the Petition. MWGen waives a hearing on the petition. MWGen's Petition is limited to a single condition change regarding the type of final cover and does not require re-visiting the Board's prior findings and decision to issue the adjusted standard.

k) As required by 35 Ill. Adm. Code 104.406(k) and (l), MWGen has provided the citations to relevant supporting documents and legal authorities and has provided required information as applicable to its request for revising Condition 7(c) of the existing adjusted standard.

IV. Conclusion

For the reasons stated, MWGen requests the Board enter an Order that maintains the existing adjusted standard but revises Condition 7(c) to allow for the ClosureTurf final cover system as described in this Petition.

WHEREFORE, Midwest Generation LLC requests that the Board grant this revision to Condition 7(c) of its adjusted standard AS-96-9.

Respectfully submitted,
Midwest Generation, LLC

By: [signature]
One of its Attorneys

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BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:

PETITION OF MIDWEST GENERATION FOR AN ADJUSTED STANDARD FROM 35 ILL. ADM. CODE PARTS 811 and 814	**AS 19-** **(Adjusted Standard-RCRA)**

INDEXT OF EXHIBITS FOR MIDWEST GENERATION, LLC'S
PETITION FOR ADJUSTED STANDARD

Exhibit 1	Opinion and Order of the Board in *In re* Petition of Commonwealth Edison Company for an Adjusted Standard from 35 Ill. Adm. Code Parts 811 and 814, (Aug. 15, 1996), AS 96-9
Exhibit 2	Affidavit of Richard Gnat of KPRG and Associates, Inc.
Exhibit 3	Affidavit of William Naglosky, the Plant Manager of Midwest Generation, LLC Joliet 9 and Joliet 29 Generating Stations
Exhibit 4	Technical Memorandum In Support of Midwest Generation, LLC's Petition for an Adjusted Standard
Exhibit 5	Petition of Commonwealth Edison Company For Adjusted Standard From 35 Ill. Adm. Code 811.814, *In re* Petition of Commonwealth Edison Company for an Adjusted Standard from 35 Ill. Adm. Code Parts 811 and 814, AS 96-6 (April 1, 1996)
Exhibit 6	Illinois Environmental Protection Agency's Response to Petition for Adjusted Standard, *In re* Petition of Commonwealth Edison Company for an Adjusted Standard from 35 Ill. Adm. Code Parts 811 and 814, AS 96-6, May 3, 1996
Exhibit 7	Petition for an Adjusted Standard, In the Matter of: Petition of Metropolitan Water Reclamation District of Greater Chicago for an Adjusted Standard from 35 Ill. Adm. Code 811, 812, and 817, and Modification of AS 95-4 (Sludge Application), AS 03-2 (Feb. 11, 2003)
Exhibit 8	Opinion and Order of the Board in In the Matter of: Petition of Metropolitan Water Reclamation District of Greater Chicago for an Adjusted Standard from 35 Ill. Adm. Code 811, 812, and 817, and Modification of AS 95-4 (Sludge Application), AS 03-2, July 24, 2003

Exhibit 9	Y. Hsuan, R. Koerner, A. Comer, "Cold Temperature and Free-Thaw Cycling Behavior of Geomembranes and Their Seams", Geosynthetic Institute White Paper #28, June 17, 2013
Exhibit 10	CTT Group, Analysis Report, SCC Accreditation No.: 40, April 18, 2017
Exhibit 11	Letter to Anna Saindon, Geotechnology, Inc. from Paul C. O'Malley, Vice-President of Sales, Watershed Geosynthetics, LLC on December 12, 2016 on "Meredosia IEPA comment on ClosureTurf"
Exhibit 12	ClosureTurf LLC-Landfill Cover System, Retained Tensile Strength v. Weathering Time. Desert Weathering, New River, AZ
Exhibit 13	G. Blaylock, "Aerodynamic Evaluations of ClosureTurf Ground Cover", Phase I Report, Georgia Institute of Technology, May 14, 2010-July 8, 2010
Exhibit 14	R. Koerner, Y. Hsuan, G. Koerner, "Geomembrane Lifetime Prediction: Unexposed and Exposed Conditions", Geosynthetic Institute White Paper #6, June 7, 2005, updated February 8, 2011
Exhibit 15	Letter to Jose Urrutia, ClosureTurf, LLC from Zehong Yuan, Laboratory Manager, SGI Testing Services on July 8, 2010 on "Evaluation of Drivability Light Weight Construction Equipment on Closure Turf Cover System"
Exhibit 16	TRI/Environmental, Inc., Client RPH, Erosion Testing Report, April 26, 2010
Exhibit 17	Watershed Geosythetics, LLC, "Summary of Benefits of ClosureTurf", undated
Exhibit 18	TRI/Environmental, Inc., Project: ASTM D6459, Client ClosureTurf, July 20, 2015
Exhibit 19	Watershed Geosythetics, LLC, "Design Life of ClosureTurf", undated
Exhibit 20	TRI/Environmental, Inc., Project: ClosureTurf with Sand-Cement Infill – Channel Lining, July 20, 2015
Exhibit 21	Letter to Jose Urrutia, ClosureTurf, LLC from Zehong Yuan, Laboratory Manager, SGI Testing Services on June 27, 2010 on "Laboratory Test Results Transmittal Interface Direct Shear Testing Closure Turf Cover System"

EXHIBIT 1

ILLINOIS POLLUTION CONTROL BOARD
August 15, 1996

IN MATTER OF:	)		
	)		
PETITION OF COMMONWEALTH	)	AS 96-9	
EDISON COMPANY FOR AN ADJUSTED	)	(Adjusted Standard - Land)	
STANDARD FROM 35 ILL. ADM. CODE	)		
PARTS 811 and 814	)		

OPINION AND ORDER OF THE BOARD (by R.C. Flemal):

This matter comes before the Board upon a "Petition for Adjusted Standards from Certain Regulations Governing Existing Landfills" filed by Commonwealth Edison Company (Edison) on April 1, 1996. The petition applies to Edison's Joliet/Lincoln Quarry Site (Lincoln Quarry or the Site).

The requested modifications apply to the following standards governing non-hazardous solid waste landfill operations: (1) the standard prescribing a leachate collection and management system; (2) the groundwater monitoring requirements for certain inorganic and organic constituents; (3) the standards for location of monitoring wells; (4) the zone of attenuation standards applicable to the Site; (5) the standard prescribing final cover for the Main Quarry; and (6) miscellaneous additional standards that Edison asserts factually do not apply to the mode of operation conducted at the Site.

The Board's responsibility in this matter arises from the Environmental Protection Act (Act) (415 ILCS 5/1 et seq.). The Board is charged therein to "determine, define and implement the environmental control standards applicable in the State of Illinois" (Act at Section 5(b)) and to "grant . . . an adjusted standard for persons who can justify such an adjustment" (Act at Section 28.1(a)). More generally, the Board's responsibility in this matter is based on the system of checks and balances integral to Illinois environmental governance: the Board is charged with the rulemaking and principal adjudicatory functions, and the Illinois Environmental Protection Agency (Agency) is responsible for carrying out the principal administrative duties.

The Act also provides that "the Agency shall participate in [adjusted standard] proceedings". (415 ILCS 28.1(d)(3).) On May 3, 1996 the Agency filed a response and recommended that the instant requested adjusted standard be granted[1].

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[1] Edison's April 1, 1996 petition for adjusted standard will be cited as (Pet. at __) and the Agency's May 3, 1996 response will be cited as (Res. at __).

Edison waived hearing in this matter pursuant to 35 Ill. Adm. Code 106.705(j). No other person requested a hearing, and accordingly no hearing was held.

Based upon the record before it and upon review of the factors involved in the consideration of adjusted standards, the Board finds that Edison has demonstrated that grant of an adjusted standard in the instant matter is warranted for 35 Ill. Adm. Code 814.302(b)(1), 811.319(a)(2), 811.319(a)(3), 811.318(b)(5), 811.320(c), and 811.314.

NATURE OF THE FACILITY AND DISCHARGE

The Lincoln Quarry, or Site, is located 1/4 mile south of the Des Plaines River in incorporated Will County, southwest of the City of Joliet and adjacent to two of Edison's coal-fired generating stations, Joliet Stations 9 and 29. (Pet. at 2.) The Site is comprised of former dolomite quarries that are now divided into three units: the Main Quarry, the North Quarry, and the West Filled Area. (*Id*.) Although the Joliet Stations generate fly ash, bottom ash, and slag as byproducts of the coal burning process, this petition only concerns the handling of bottom ash and slag. Fly ash is shipped off-site for disposal.

Edison deposited bottom ash and slag into the West Filled Area prior to 1975. The West Filled Area has since been leveled and vegetated. Since 1975 Edison has deposited the bottom ash and slag into the Main Quarry, which was permitted as a landfill for coal combustion wastes in 1976. The bottom ash and slag are mixed with water from the Des Plaines River (River) and then sluiced into the Main Quarry. Edison maintains the water level in the Main Quarry between 549 feet and 555 feet above sea level, approximately 20 to 30 feet below the adjacent groundwater table. The difference in water level generates a hydraulic gradient that is directed into the Main Quarry. That is, the groundwater flows into the Main Quarry from the surrounding aquifer. From the Main Quarry the water drains by gravity into the North Quarry settling pond and finally the sluicing water is pumped back into the River (under NPDES permit #IL0002216). (Pet. at 3.)

BACKGROUND

As required under 35 Ill. Adm. Code 814.103, Edison notified the Agency that it would be closing the Lincoln Quarry by September 18, 1997. (Pet. at 3-4.) However, due to the unanticipated capacity, Edison now believes that it can receive ash wastes from the Joliet Stations well beyond the expected useful life of those Stations. (*Id*.) As a result, Edison amended its notification to extend the closure date of the coal combustion waste monofill at the Lincoln Quarry beyond September 18, 1997.

As a result of Edison's closure extension, it was required to show that the Lincoln Quarry would satisfy the standards applicable to existing landfills under 35 Ill. Adm. Code 814, Subpart C. (Pet. at 4.) However, Edison states that as its mandatory application for significant modification indicated, Lincoln Quarry cannot satisfy some of these standards. (*Id*.)[2]

In the instant adjusted standard, Edison argues that the generally applicable standards at issue cannot rationally apply to the operations in the Main Quarry. In addition, it claims that such compliance would require structural modifications to the Main Quarry which are technically and economically impracticable for what amounts to a questionable environmental benefit. (Pet. at 5.)

ADJUSTED STANDARD PROCEDURE

The Illinois Environmental Protection Act at Section 28.1 (415 ILCS 5/28.1 (1994)) provides that a petitioner may request, and the Board may impose, an environmental standard that is different from the standard that would otherwise apply to the petitioner as the consequence of the operation of a rule of general applicability. Such a standard is called an adjusted standard. The general procedures that govern an adjusted standard proceeding are found at Section 28.1 of the Act and within the Board's procedural rules at 35 Ill. Adm. Code Part 106.

The standards from which Edison seeks modification do not specify a level of justification or other requirement for an adjusted standard for this matter. Therefore, Sections 28.1(c)(1) through (c)(4) of the Act are relevant in this proceeding. Petitioner has the burden of proving the following for an adjusted standard from a rule of general applicability:

1. factors relating to that petitioner are substantially and significantly different from the factors relied upon by the Board in adopting the general regulation applicable to the petitioner;

2. the existence of those factors justifies an adjusted standard;

3. the requested standard will not result in environmental or health effects substantially and significantly more adverse than the effects considered by the Board in adopting the rule of general applicability; and

4. the adjusted standard is consistent with any applicable federal law.

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[2] Edison originally filed a site-specific rulemaking with the Board, R94-30, which was subsequently withdrawn after negotiations with the Agency determined that Edison no longer needed relief from the groundwater quality standards. (Pet. at 5.)

REQUESTED ADJUSTED STANDARD

Section 814.302(b)(1)

Edison requests an adjusted standard from the rule-of-general applicability at 35 Ill. Adm. Code 814.302(b)(1), which states:

***

b) Units regulated under this Subpart shall be subject to the following standards:

1) The unit must be equipped with a system which will effectively drain and collect leachate and transport it to a leachate management system.

***

Leachate is defined in the regulations as a "liquid which has been or is in direct contact with a solid waste". (35 Ill. Adm. Code 810.103.) Under this definition, Edison handles approximately 8.5 million gallons of leachate per day through its current gravity flow system. According to Edison this is a high volume of leachate, as compared to an average landfill which handles approximately 1000 gallons per acre per day. (Pet. at 50.) It is this substantial daily water inflow at Edison's inward-gradient landfill that justifies its current tailored leachate collection and management system.

Under the present regulations Edison would be required to drain, collect and transport the approximately 8.5 million gallons per day of sluice water, groundwater, and precipitation, all which flow directly or indirectly to the Main Quarry. (Pet. at 49.) Under the proposed adjusted standard Edison would manage the water through its current gravity-flow drainage system. This system includes drainage pipes which draw water from the Main Quarry into the North Quarry and a pumping station which discharges that water from the North Quarry into the River. (Pet. at 62.) This system captures all but 101,400 gallons per day, or 1.2% of the water volume reaching the Site. (*Id*.) According to Edison, installing any alternative leachate collection and management system to capture only the incremental water would "result in little, if any, discernible environmental benefit". (Pet. at 63.) The cost of using the gravity-flow system would be $150,000 per year at present value, including capital costs to replace slag lines and pumps, and operating costs for the pumps. (*Id*.)

Any additional compliance system which Edison puts in place would address the incremental water which bypasses its present gravity-flow system. Furthermore, Edison claims that any alternative or additional leachate system would simply change the path of the leachate, but it would still flow to the same destination. Specifically, the leachate which would under the proposed adjusted standard flow from the bedrock directly into the River, would instead flow first to its leachate management system and then discharge into the River. (Pet. at 63-64.) According to Edison there are no known wells or other known environmental receptors in the region of the Site. (Pet. at 63.)

Edison examined various alternatives to its current gravity-flow system (Pet. at 51-62) and found those leachate collection and management systems to be "prohibitively expensive and present significant technological challenges". (Pet. at 51).

Initially Edison evaluated the traditional leachate collection systems and found them to be incompatible with its current operating practices. Edison sluices its ash waste into the Main Quarry and operates the Quarry as a surface impoundment. (Pet. at 51.) A traditional leachate system requires restricting the amount of water that reaches the waste. Specifically, Edison examined and rejected two traditional landfill methods to collect leachate: (1) an underdrainage system located beneath the waste and above a low permeability bottom liner in newer landfills, and (2) leachate recovery wells drilled into the waste from the top of existing or older landfills.

First, the underdrainage system could be installed either above the existing waste to collect and manage leachate for future waste placement, or below the existing waste. Installing it above the current waste would not effectively address the groundwater which would continue to enter the Main Quarry and migrate downgradient after flowing through the waste. (Pet. at 52.) Edison could install the underdrainage system, which would involve removing the existing waste, lining the fractured dolomitic rock base and walls of the Main Quarry, and installing a low-permeability layer and leachate collection system. (Pet. at 52.) Edison detailed the specifics of removing the ash, and cited the problems associated with relocating the wet ash into not-yet constructed settling basins, including extensive dewatering at the Quarry throughout the installing period, dredging the settling basin, and the possibility of having to store the large volume of ash offsite. (Pet. at 52-56.) Once all of the ash was finally removed, Edison would install a three-phase leachate control system consisting of a groundwater gradient control layer, a low-permeability liner system, and a leachate system on the sides and bottom of the Quarry bedrock. Any new ash deposited into the Quarry would have to be under dry, and not wet, ash handling practices. When considering an underdrainage system, Edison is unclear of the potential environmental harms. For example risks associated with handling dry ash at the Site such as increased worker exposure to ash waste, increased truck traffic between the settling basin and the Main Quarry, and dust generated by dumping the dry ash into the dry Quarry. (Pet. at 56.)

Second, Edison examined the possibility of installing leachate recovery wells drilled into the waste from the top of the landfill, at or near the downgradient boundary of the disposal cell to pump leachate from the waste into a leachate management system. (Pet. at 57-59.) Edison found such pumping wells not technically viable for the Site due to the fact it uses a wet disposal method. Under the current wet disposal system, 8.6 million gallons per day of sluice water, precipitation, and groundwater saturate the ash in the Main Quarry. It would be impossible for Edison to remove such a large amount of leachate daily through collection wells. (Pet. at 57.) Additionally, Edison believes such placement of the well would create a localized inward hydraulic gradient which, through pumping, would draw additional sluice water, precipitation, and groundwater through the ash to the well, increasing the amount of leachate in the Main Quarry and suspended sediments which flow from the Main to the North Quarry. (*Id*.)

Edison found that converting its system to dry ash collection, to take advantage of leachate recovery wells would create a series of other associated difficulties. Those difficulties include converting several other surrounding wells, adding additional wells, and maintaining the water level below the River level. (Pet. at 58-59.) Both wet and dry systems face significant obstacles to any installation of collection wells, such as dewatering the ash and using barges to access the north wall of the Quarry for well installation.

Edison also examined a variety of other more advanced leachate management technologies and likewise found them to be "technologically impracticable and cost prohibitive at the Lincoln Quarry Site". (Pet. at 59-62.) Those technologies included a leachate collection trench, which proved to be prohibitively expensive to install, and a downgradient drainage gallery tunnel, with drain holes to accumulate leachate seepage from fractures and joints in rock walls, which may not even be technically feasible. (Pet. at 60-62.)

As an alternative to compliance with Section 814.302(b)(1) Edison proposes to operate a leachate collection system at the Lincoln Quarry Site which assures that the water level in the Main Quarry is maintained below the natural watertable level, assures that the leachate is discharged to the Des Plaines River through Edison's NPDES-permitted outfall, and assures that Edison has properly complied with all effluent limitations in the NPDES permit. (Pet. at 12.)

The Board finds that, given the configuration of Edison's Site, and the need to handle almost 8.5 million gallons of water per day, it is impracticable to require compliance with 35 Ill. Adm. Code 814.302(b)(1). The Quarry configuration, including the differences in the flow regime, mode of operations, and waste characteristics, are substantially different from the factors upon which the Board relied in adopting this general regulation. Moreover, the adjusted disposal system proposed by Edison does not appear to result in any environmental or health effects substantially more adverse then those considered by the Board in initially adopting Section 814.302(b)(1).

Section 811.319(a)(2) and Section 811.319(a)(3)

Edison requests an adjusted standard from the rule-of-general applicability at 35 Ill. Adm. Code 811.319(a)(2), which states:

> 2) Criteria for Choosing Constituents to be Monitored
>
> > A) The operator shall monitor each well for constituents that will provide a means for detecting groundwater contamination. Constituents shall be chosen for monitoring if they meet the following requirements:

i) The constituent appears in, or is expected to be in, the leachate; and

ii) The Board has established for the constituent a public or food processing water supply standard, at 35 Ill. Adm. Code 302, the Board has established a groundwater quality standard under the Illinois Groundwater Protection Act (Ill. Rev. Stat. 1991, ch. 111 1/2, par. 7451 et seq. [415 ILCS 55/1 et. seq.]), or the constituent may otherwise cause or contribute to groundwater contamination.

B) One or more indicator constituents, representative of the transport processes of constituents in the leachate, may be chosen for monitoring in place of the constituents it represents. The use of such indicator constituents must be included in an Agency approved permit.

Along with subsection (a)(2) above, Edison requests an adjusted standard from 35 Ill. Adm. Code 811.319(a)(3), which states:

3) Organic Chemicals Monitoring

The operator shall monitor each existing well that is being used as a part of the monitoring well network at the facility within one year of the effective date of this Part, and monitor each new well within the three months of its establishment. The monitoring required by this subsection shall be for a broad range of organic chemical contaminants in accordance with the procedures described below:

A) The analysis shall be at least as comprehensive and sensitive as the tests for:

i) The 51 organic chemicals in drinking water described at 40 CFR 141.40 (1988), incorporated by reference at 35 Ill. Adm. Code 810.104; and

ii) Any other organic chemical for which a groundwater quality standard or criterion has been adopted pursuant to Section 14.4 of the Act or Section 8 of the Illinois Groundwater Protection Act.

B) At least once every two years, the operator shall monitor each well in accordance with subsection (a)(1)(A).

C) The operator of a MSWLF unit shall monitor each well in accordance with subsection (a)(1)(A) on an annual basis.

Edison argues that the concerns which underlie the monitoring requirements in the Board's landfill regulations do not apply to the Lincoln Quarry. Consequently, Edison requests that the Board limit the groundwater monitoring requirements applicable to the Site. Edison claims that the groundwater monitoring program was established to ensure that constituents from landfill wastes do not migrate into and degrade the groundwater. This migration is especially important when the wastes within the landfill vary significantly (i.e. municipal landfill), or where the waste constituent or the constituent migration pathways are poorly characterized. (Pet. at 65-66.)

However, Edison asserts that an adjusted standard is warranted because it has operated the Lincoln Quarry as a coal combustion waste monofill for over 20 years, and has fully characterized the ash waste and groundwater constituents derived from that waste (the composition of combustion wastes deposited at the site has remained generally consistent, although the specific percentages of each constituent in the ash varies somewhat). (Pet. at 65-66.) Accordingly this should eliminate the Board's primary concerns regarding characterizing the groundwater composition or impact on the environment of leachate from the landfill. (*Id*.)

Edison also claims the Board's requirement of broad based organic and inorganic constituent monitoring is not necessary at the Site because studies show no organic parameters, or volatile or semi-volatile organic compounds in the groundwater sampling. (Pet. at 65-67.) The ash samples contained primarily silicon, iron, aluminum, calcium, potassium, magnesium, sulfur, sodium, barium, and boron. (Pet. at 66.) Edison argues that it is economically unreasonable to require it to monitor groundwater for organic and inorganic constituents that could have no environmental impact. As stated, there are no organic constituents in its coal combustion waste. (Pet. at 67.)

The cost for organic groundwater sampling and testing for all the regulatorily required parameters would cost approximately $46,000 per year, as compared to the $1,000 per year ash sampling proposed in Edison's petition for adjusted standard which would sufficiently examine the organic composition of its combustion waste to predict whether this waste could impact the groundwater. (*Id*.) According to Edison, the cost to analyze the groundwater for the regulatory parameters regarding inorganic constituents would cost approximately $28,600 per year, versus the proposed testing at $16,640 per year cost to analyze only the potentially impacted parameters plus alkalinity. (Pet. at 68.)

Edison's proposed adjusted standard would waive the organic constituent requirement of 35 Ill. Adm. Code 811.319, and would only require Edison to annually sample for semi-volatile organic compounds which could remain in the bottom of ash and slag, and report these results to the Agency, and to institute sample of the semi-volatile organic constituents if necessary. (Pet. at 14 and 68.) Edison feels it is unnecessary to sample for volatile organic compound because they are destroyed in the combustion process.

Edison's proposed adjusted standard also limits the frequency of the groundwater sampling for inorganic constituents. Edison proposes to quarterly monitor the inorganic constituents of which it has detected statistically significant increases over background concentrations in downgradient wells. (Pet. at 68-69.) The other inorganic constituents regulated within 35 Ill. Adm. Code 811.319(a)(2), those whose parameters were not detected in the groundwater or were found not to have a statistically significant increase in parameter concentrations over background levels, would be sampled annually simply to verify that the groundwater composition remains constant. (Pet. at 68-71.) Specifically, Edison proposes to sample, on an annual basis, all constituents for which the Board has established Class II groundwater standards; if a statistically-significant increase in any of the concentrations is shown, then Edison proposes to add those parameters in the sampling mode prescribed at Section 811.391(a)(1). (Pet. at 13.)

Edison argues that its proposed monitoring plan, eliminating organic chemical monitoring of groundwater and focusing primarily on inorganic monitoring of those potentially impacted parameters at the Site, provides environmental protection comparable to the Board's generally applicable standards. (Pet. at 69-71.) It reasons that "[i]f those [organic] constituents are absent, eliminating the monitoring requirement for those constituents would have no environmental impact". (Pet. at 70.) Edison also observes that, because of the consistency and predictability of the groundwater concentrations of parameters attributable to the Site, "if previous monitoring results did not detect a particular inorganic constituent in Site groundwater, it is improbable that that constituent would appear in future sampling events". (Pet. at 70.) As for those inorganic parameters which have been detected at the Site, Edison claims that the "groundwater concentrations should remain constant or decrease over time as the leachable concentrations of those parameters in the ash decreases". (Pet. at 70.)

Edison's proposed monitoring plan, given the frequency and type of groundwater monitoring, appears to be adequate to justify the grant of an adjusted standard. The Site presents factors substantially and significantly different from the factors the Board considered in adopting the landfill groundwater monitoring requirements with regard to choosing the constituents to be monitored and organic chemical monitoring. Given the absence of organic chemicals and consistency of constituents for almost 20 years in this monofill, the concerns which underlie the monitoring requirements in the Board's landfill regulations are not present at the Lincoln Quarry. The Board accordingly believes Edison has demonstrated that the instant groundwater monitoring requirements, Section 811.319(a)(2) and Section 811.319(a)(3), warrant an adjustment suitable to the Site. The Board also finds that Edison's proposed alternative standards provide environmental protection comparable to that contemplated under the rule of general applicability.

<u>Section 811.318(b)(3) and Section 811.318(b)(5)</u>

Edison requests an adjusted standard from the rule-of-general applicability at 35 Ill. Adm. Code 811.318(b)(3), which states:

b) Standards for the Location of Monitoring Points

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3) Monitoring wells shall be established as close to the potential source of discharge as possible without interfering with the waste disposal operations, and within half the distance from the edge of the potential source of discharge to the edge of the zone of attenuation downgradient, with respect to groundwater flow, from the source.

Edison also requests an adjusted standard from 35 Ill. Adm. Code 811.318(b)(5), which states:

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5) A minimum of at least one monitoring well shall be established at the edge of the zone of attenuation and shall be located downgradient with respect to groundwater flow and not excluding the downward direction, from the unit. Such well or wells shall be used to monitor any statistically significant increase in the concentration of any constituent, in accordance with Section 811.320(e) and shall be used for determining compliance with an applicable groundwater quality standard of Section 811.320. An observed statistically significant increase above the applicable groundwater quality standards of Section 811.320 in a well located at or beyond the compliance boundary shall constitute a violation.

Edison claims that due to physical constraints at the Lincoln Quarry, it is unable to install the large number of groundwater monitoring wells required in the above regulations. Specifically, if the Board grants Edison its request to adjust the zone of attenuation for the Site, Edison will be unable to install a well at the edge of the adjusted zone. (Pet. at 72.)

Edison argues that the landfill conditions relied upon the Board in adopting these regulations are not the conditions which exist at Edison's Site. First, the landfill regulations assume a lined landfill located in a porous media, where groundwater flow rates and physico-chemical processes of soil attenuation are consistent and the entire site can be easily modeled with limited flow volumes. (Pet. at 73-75.) In contrast, the Site is located in fractured dolomitic rock. The type of limited groundwater monitoring required in the regulations would not present an accurate picture of the constituent transport. On the whole, the groundwater flow rates through the rock at the Site are very slow; however, flow rates within individual fractures and bedding planes can be very rapid. (*Id*.) As a result of this widely divergent ground formation, Edison believes an accurate representation of the Site's water bearing material can only be achieved through a large-scale modeling process, unlike that required in Section 811.318.

Secondly, Edison argues that due to the terrain surrounding the Site, it would be technically impracticable and economically unreasonable to install a groundwater monitoring system which would comply with the Board's landfill regulations. (Pet. at 76-78.) For instance, there are physical obstacles (screening berms and security fencing) and natural environmental barriers (sheer vertical dolomite faces and deep ponds) within 100 feet downgradient of the Main Quarry boundary. Most significantly Edison explains that there exists a narrow strip of land between the Main and North Quarries which provides insufficient access for well drilling equipment and personnel safety to install a network of wells. Regardless of the physical constraints preventing well installation, Edison claims that any constituent migration or groundwater flow data would not likely be accurate. (Pet. at 76-77.) Due to the quarrying and other land use activities which have altered the natural groundwater flow patterns, and differences in the hydraulic gradients between the Main and North Quarries, any wells installed in this area would give atypical information regarding the entire Site. (*Id*.) Given the unlikelihood the required wells will provide meaningful monitoring data, Edison argues that it should not be required to expend capital to install such wells.

Lastly, Edison states that if the adjusted zone of attenuation is granted, it would be technically impracticable to install wells at the edge of the zone. The adjusted zone of attenuation boundary is contiguous with the northern-most property boundary and is located at, or sometimes beyond, the banks of the Des Plaines River. Because of its proximity to the River and subsequent mixing of groundwater and River water, installing monitoring wells in this area would not provide reliable data regarding the pertinent constituents, nor allow access for drill equipment or personnel. (Pet. at 77.)

According to Edison, it would be required to install 30 new groundwater monitoring wells to comply with the Board's regulations, at an estimated total cost of $300,000. (Pet. at 77.) Edison proposes to install a groundwater monitoring network, which instead of placing wells at or near the locations prescribed by the Board's regulations, will place the wells beyond the regulatory 100-foot standard and within the North Quarry. Specifically, Edison will continue to use ten existing wells[3] at the Site.

Edison claims that although it cannot install all of the regulatorily required wells, it can "establish a network of groundwater monitoring wells that protects the environment" (Pet. at 72), and which comprehensively and accurately depicts constituent migration at the Site. Edison states that the River is the only significant environmental receptor for groundwater at the Site. To accurately determine the groundwater flow to the River; Edison believes it is necessary to install monitoring wells under the North Quarry (as proposed in its adjusted standard request), as opposed to 100 feet from the Main Quarry (as required in the regulations)

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[3] The pre-existing wells are: upgradient wells 92-2S and 92-2D in the South Quarry, and downgradient wells: nested wells R08S and R08D northwest of the Quarry, nested wells 92-5S and 92-5D north of the Main Quarry, nested wells G20S and R16D northeast of the Quarry, well 93-9 north of the Quarry, and well 93-11 northwest of the Quarry.

or as opposed to the northern boundary line of the proposed adjusted standard. (Pet. at 78-80.) Only by installing wells under the North Quarry can Edison measure the water that bypasses its pumping system and flows directly into the River. If the wells were placed under or near the Main Quarry, it would primarily measure the groundwater which is flowing to the North Quarry due to pumping. Edison argues that its proposed network of monitoring wells satisfies the Board's environmental objectives of monitoring environmentally relevant constituent flow at the Site. (Pet. at 80.)

The Board finds that Edison has presented sufficient justification for an adjusted standard from Sections 811.318(b)(3) and Section 811.318(b)(5). The conduits present in such fractures provide for groundwater flow quite distinct from the flow in homogenous porous media. Such a significantly different groundwater flow regime was not the type considered by the Board in adopting the rule of general applicability. The Board acknowledges that a altered groundwater monitoring network may be required. Indeed the physical location of the Site with relation to the River in addition to the unique widely divergent ground formation at the Quarries, justify an adjusted standard.

<u>Section 811.320(c)</u>

Edison requests an adjusted standard from the rule-of-general applicability at 35 Ill. Adm. Code 811.320(c), which states:

c) Determination of the Zone of Attenuation

1) The zone of attenuation, within which concentrations of constituents in leachate discharged from the unit may exceed the applicable groundwater quality standard of this Section, is a volume bounded by a vertical plane at the property boundary or 100 feet from the edge of the unit, whichever is less, extending from the ground surface to the bottom of the uppermost aquifer and excluding the volume occupied by the waste.

2) Zones of attenuation shall not extend to the annual high water mark of navigable surface waters.

3) Overlapping zones of attenuation from units within a single facility may be combined into a single zone for the purposes of establishing a monitoring network.

As alternative to compliance with Section 811.320(c), Edison proposes a zone of attenuation that is 100 feet from the edge of the Lincoln Quarry on the upgradient side and at the property boundary on the downgradient side. (Pet. at 14.) Edison believes this proposed zone of attenuation, coupled with the proposed monitoring well location standards discussed above, and an agreement with the Agency to establish a groundwater management zone (GMZ) at the Site, will be consistent with the Board's current definitions and regulations. (*Id*.)

The proposed zone is supported twofold: first, it places "all relevant site features that potentially contribute to elevated constituent concentrations in groundwater within a single zone of attenuation for the Site"; and the zone will be contiguous with the GMZ. (Pet. at 86.) The Agency has agreed to designate the Lincoln Quarry Site from the waste boundary to the site boundary as a GMZ (apparently to address exceedences of background concentrations).

Edison states two reasons to justify a modification from the landfill standards relating to the zone of attenuation. First, Edison argues that the Board did not consider water flow conditions like those present at the Site in defining the generally applicable zone of attenuation. (Pet. at 81-83.) Specifically, Edison claims the Site consists of fractured rock, where, unlike in the Board's models, groundwater flow rates vary considerably. Accordingly the "degree to which attenuation and hydrodynamic dispersion can occur under these conditions depends upon the existence, number, properties, and relationship between discontinuities in the rock mass". (Pet. at 82.) Edison argues that the "geochemical processes of attenuation are of little or no significance at Lincoln Quarry because there is little interaction between the chemical constituents and the rock mass". (*Id*.)

Second, Edison argues that retaining the zone of attenuation at the 100 foot boundary would cause it to incur tremendous expense for minimal environmental benefit. (Pet. at 83-85.) Groundwater degradation over background concentrations already exists beyond the Main Quarry[4] due to disposal of flyash in the West Quarry and lack of attenuation. Therefore groundwater downgradient of the Site beyond the 100-foot zone of attenuation will continue to exceed the Board's non-degradation standard (particularly for boron and sulfate) regardless of whether Edison takes additional precautions. (Pet. at 83-84.) As a result, Edison believes it is "technically impracticable to establish the zone of attenuation as required by the generally applicable standards". (Pet. at 83.)

Edison examined several different options to bring the Quarry into partial or complete compliance with groundwater standards at the edge of the zone of attenuation. The options considered include: converting the facility from sluiced to dry disposal and constructing a new landfill on the existing ash designed in compliance with the standards in Section 811; closing the landfill and contracting for off-site ash disposal at existing facilities; closing the landfill and the generating stations; or closing the landfill and constructing a new off-site landfill for ash disposal. (Pet. at 84.) According to Edison each of the these compliance alternatives present severe adverse economic and/or social impacts for limited, if any, environmental benefit. (*Id*, see also Exhibit 12)

Edison notes that none of the compliance alternatives studied would address the groundwater impacts from prior waste operations which account for exceedences at the edge of

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[4] Ammonia, arsenic, boron, cadmium, chloride, fluoride, manganese, molybdenum, pH, potassium, selenium, sodium, sulfate, total dissolves solids, total organic carbon and zinc.

the zone of attenuation. Edison believes those constituent concentrations would either remain constant or decrease over time, but would not decrease significantly immediately. (Pet. at 85.) Therefore, Edison would still need to request an adjusted zone of attenuation. If it desired to reduce the existing concentrations it could excavate the waste currently in the Main Quarry and West Filled Area (at a cost estimate $65-187 million) or install a leachate/groundwater collection system. Edison believes neither option is economically reasonable.

Edison claims that the proposed zone of attenuation extension will adequately protect the environment. (Pet. at 86-88.) It claims that the only environmental receptor affected by the increase in the zone of attenuation is the River. The current constituent concentrations in groundwater have "no discernible impact on water quality in the Des Plaines River". (Pet. at 86.) Additionally, the contribution of constituents attributable to groundwater discharges which enter the River are indistinguishable from natural incremental deviations which are normally expected. Edison claims that "current discharges from the Site have no impact on River concentrations of constituents". (Pet. at 87.)

Edison also proclaims that the "proposed zone of attenuation does not impact any known or potential environmental receptors". (Pet. at 88.) It states there will be no environmental impact on the area between the original and proposed zone, primarily because there are no current uses for impacted groundwater downgradient of the Site. (Pet. at 87-88.) In addition to current uses, the future use of this groundwater is also unlikely because Edison owns or controls most of the pertinent land, the impacted surrounding land is industrialized and unsuitable for residential development, and there exists an unimpacted, deeper acquirer to be used in the future.

The Board's rule of general applicability at Section 811.320(c) is premised on the presence of an attenuating porous media, which differs from the fractured and jointed bedrock that occurs at the Lincoln Quarry Site. In this circumstance, and in light of the chemistry of the Lincoln Quarry waters and the local nature of the groundwater flow system, the Board believes that adjusting the downgradient zone of attenuation to the northern property is justified. Moreover, because Edison commits to controlling future use of the groundwater, it appears granting the requested adjusted standard will not result in environmental or health effects substantially more adverse than the effects considered by the Board in adopting the rule of general applicability.

Section 811.314

Edison requests an adjusted standard from the rule-of-general applicability at 35 Ill. Adm. Code 811.314, which states:

a) The unit shall be covered by a final cover consisting of a low permeability layer overlain by a final protective layer constructed in accordance with the requirements of this Section.

b) Standards for the Low Permeability Layer

1) Not later than 60 days after placement of the final lift of solid waste, a low permeability layer shall be constructed.

2) The low permeability layer shall cover the entire unit and connect with the liner system.

3) The low permeability layer shall consist of any one of the following:

A) A compacted earth layer constructed in accordance with the following standards:

i) The minimum allowable thickness shall be 0.91 meter (3 feet);

ii) The layer shall be compacted to achieve a permeability of $1x10^{-7}$ centimeters per second and minimize void spaces.

iii) Alternative specifications may be utilized provided that the performance of the low permeability layer is equal to or superior to the performance of a layer meeting the requirements of subsections (b)(3)(A)(i) and (b)(3)(A)(ii).

B) A geomembrane constructed in accordance with the following standards:

i) The geomembrane shall provide performance equal or superior to the compacted earth layer described in subsection (b)(3)(A).

ii) The geomembrane shall have strength to withstand the normal stresses imposed by the waste stabilization process.

iii) The geomembrane shall be placed over a prepared base free from sharp objects and other materials which may cause damage.

C) Any other low permeability layer construction techniques or materials, provided that they provide equivalent or superior performance to the requirements of this subsection.

4) For a MSWLF unit, subsection (b)(3) notwithstanding, if the bottom liner system permeability is lower than 1 x 10^{-7} cm/sec. the permeability of the lower permeability layer of the final cover system shall be less than or equal to the permeability of the bottom liner system.

c) Standards for the Final Protective Layer

1) The final protective layer shall cover the entire low permeability layer.

2) The thickness of the final protective layer shall be sufficient to protect the low permeability layer from freezing and minimize root penetration of the low permeability layer, but shall not be less than 0.91 meter (3 feet).

3) The final protective layer shall consist of soil material capable of supporting vegetation.

4) The final protective layer shall be placed as soon as possible after placement of the low permeability layer to prevent desiccation, cracking, freezing or other damage to the low permeability layer.

Edison claims that the Board's generally applicable cover requirements do not apply to conditions at the Lincoln Quarry due to the mode of operation at the site. (Pet. at 88-94.) Edison examined the following environmental objectives in coming to that conclusion: minimization of water percolation and infiltration into the waste, control of water run-off from the cover, maximization of evapotranspiration, control of landfill gas and prevention of cover erosion, and minimization of maintenance.

For instance, minimizing water percolation and infiltration into the waste would not be accomplished with a Section 811.314 cover because the water reaching the Quarry comes from natural groundwater flows, not infiltration or percolation. (Pet. at 90.) The objectives of the impermeable layer and the final cover include minimization of water percolation and infiltration into the waste as well as controlling landfill gas and control of the runoff water. At the Site the water infiltration through percolation is relatively small compared to the groundwater infiltration into the waste area. Given the fractured rock and dolomite at the Site, along with the difference in water level in the Quarry and the adjacent groundwater table, the natural groundwater flows from the south through the Quarry to the River. A landfill cover system would reduce, but not eliminate the amount of water which reaches the bottom ash and slag due to precipitation. (Pet. at 91.) Maximizing evapotranspiration is not a factor at the Site because the majority of the water reaches the waste through groundwater inflow and not precipitation. (Pet. at 92.) The effect of the very small additional amount leachate through precipitation on downgradient groundwater quality would be undetectable.

Because the wastes in the Quarry contain no organic constituents that might produce gases through decomposition, the type of cover system required in Section 811.314 is not necessary to control the gas. The waste at the Quarry contains only non-putrescible industrial wastes consisting of inorganic constituents, primarily oxides of silicon, aluminum, iron and calcium. (Pet. at 93.) Therefore, there is no need to control landfill gas because the coal combustion byproducts do not produce methane through decomposition as organic constituents.

Another environmental objective examined, the prevention of cover erosion and minimization of maintenance, would require significant upkeep and maintenance at the Site because of the hydraulic conditions, particularly the fact that pressures caused by groundwater flow into the landfill could degrade the required cap. (Pet. at 93-94.)

Edison argues that it would be technically impracticable and economically unreasonable to install a final cover system satisfying the generally applicable requirements for the Main Quarry. (Pet. at 94-98.) Edison examined the two alternatives which satisfy the Board's final cover requirements. First, the installation of a compacted earth low-permeability layer covered by three feet of soil. And second, the installation of a geomembrane liner covered by three feet of soil. Edison thoroughly examined the scenario of installing a cap using a wet closure and a dry closure with a total closure cost of $20-28 and $8 million respectively.

Lastly, Edison describes the proposed "Closure and Post-Closure Care Plan". (Pet. at 98-101.) Edison presents two possible options during closure, where the ash level in the Main Quarry is below and above the water level. If the ash level is below the water level for the groundwater table, Edison would close the landfill in its present "wet" condition. It would place a fence around the Site to prevent access and maintain the water at a level in the Quarry which supports the current inward hydraulic gradient. This would be the least costly alternative providing comparable environmental benefits. If the level of ash in the Main Quarry is above the natural groundwater table, Edison would install a two-stage cover system consisting of a "compacted clay layer that performs equivalently to two feet of compacted soil having a hydraulic conductivity of 1 x 10 -7 cm/sec, overlain by at least four inches of topsoil. The cap would be sloped at no less than a two percent grade and would be seeded to prevent erosion." (Pet. at 100.)

Edison alleges that its proposed final cover standards in the request for adjusted standard will provide environmental benefits that are comparable to those obtained under the generally applicable final cover standards at a lower cost. (Pet. at 101-105.)

The Board agrees that Edison's operation at the Site does not lend itself to compliance with the Section 811.314 final cover requirements. The required impermeable layer and final cover operate to minimize water percolation and infiltration into the waste, and to control landfill gas and runoff water. At the Edison Site water infiltration through percolation is relatively small compared to the groundwater infiltration into the waste area. It therefore appears that there would be no environmental benefit to installing cover pursuant to this section.

With regards to controlling landfill gas, Edison's current discharges are only coal combustion byproducts with no organic constituents that might produce methane through decomposition. Therefore, there is no need to require control of landfill gas at the Quarry.

"Attachment A" Standards (Sections 811.105, 811.106, 811.107(a), 811.107(b), 811.107(i), 811.310, 811.311, 811.312, 811.313, 811.321, and 811.322)

Edison includes as part of its overall petition request that the Board find certain parts of the Board's landfill regulations be found to not apply to the Site. For the purposes of discussion, these will be referred to the at the "Attachment A" standards, based on their presentation in Attachment A of Edison's petition. (Pet. at 110, Attachment A.) The regulations at issue are 35 Ill. Adm. Code Section 811.105 (compaction of waste), 811.106 (daily cover), 811.107(a) (phasing of operations), 811.107(b) (working face), 811.107(i) (vector control), 811.310, 811.311, 811.312 (landfill gas monitoring and management system), 811.313 (intermediate cover), 811.321 (waste placement), and 811.322 (final slopes and stabilization).

The Board notes that Edison's request regarding the Attachment A standards differs from its request regarding the main portion of the instant adjusted standard in that Edison does not seek to replace the Attachment A standards with alternate, site-specific standards. Rather, Edison requests that the Board "confirm that these standards do not apply to Lincoln Quarry" and to find that "Edison's current management practices adequately satisfy the purposes behind these requirements". (Pet. at 110.)

In addition, Edison's request regarding the Attachment A standards differs from its request regarding the main portion of the instant adjusted standard in that Edison does not attempt to make the demonstrations required at Section 28.1(c) of the Act for any of the Attachment A requests.

AGENCY RESPONSE

The Agency believes that the factors relating to Edison with regards to the applicable standards are substantially and significantly different from the factors upon which the Board relied upon in adopting the regulations of general applicability. (Res. at 4.)

The Agency agrees that compliance with the applicable standards would be economically unreasonable and, with respect to some of the standards, technically infeasible for Edison to accomplish. (Res. at 3.) Moreover, the Agency states that it has "no basis for challenging Edison's cost analyses". (*Id*.)

The Agency agrees with Edison that granting the adjusted standard will not have an adverse impact on the environment and specifically will not result in environmental or health effects substantially and significantly more adverse than the effects considered by the Board when adopting the rule of general applicability. (Res. at 1-5.)

The Agency agrees with Edison that the Board may grant the adjusted standard consistent with applicable federal law. (Res. at 4-5.)

CONCLUSION

The Board finds that Edison has demonstrated that grant of the adjusted standard requested by Edison is warranted.

Regarding the request for adjusted standard from 35 Ill. Adm. Code 814.302(b)(1), 811.319(a)(2), 811.319(a)(3), 811.318(b)(5), 811.320(c), and 811.314, the Board finds that Edison has made the demonstrations required under Section 28.1(c) of the Act. In reaching this decision, the Board finds it noteworthy that Edison proposes and agrees to abide with a series of replacement standards. The Board believes these replacement standards will provide environmental protection at least equivalent to that which flows from the current regulations. The Board will accordingly condition grant of the adjusted standard upon Edison's compliance with the replacement standards.

As regards the Attachment A parameters, the Board will grant Edison's request that we determine "that these standards do not apply to Lincoln Quarry". (cf. In the Matter of Wood Energy, AS 94-1 (October 6, 1994), esp. footnote 3). We will not grant an "adjusted standard" as such, since as we have noted above, Edison does not attempt to make the demonstrations required by Section 28.1(c) of the Act, and we do not wish to establish a precedent of acceptance of inadequate pleading in these cases. However, the Board believes that none of these standards are reasonably applicable to the circumstances encountered in the Lincoln Quarry disposal system. We will instead include in the order of adjusted standard a statement that the attachment A standards do not apply.

This opinion constitutes the Board's findings of fact and conclusions of law in this matter.

ORDER

Commonwealth Edison Company is hereby granted an adjusted standard for the Joliet/Lincoln Quarry Site with respect to the following regulations: 35 Ill. Adm. Code 814.302(b)(1), 811.319(a)(2), 811.319(a)(3), 811.318(b)(5), 811.320(c), and 811.314.

In addition, the following Board regulations do not apply to the Joliet/Lincoln Quarry Site: 35 Ill. Adm. Code 811.105, 811.106, 811.107(a), 811.107(b), 811.107(i), 811.310, 811.311, 811.312, 811.313, 811.321, and 811.322.

In lieu of the standards above the following shall apply.

1) Edison shall dispose only bottom ash and slag from the combustion of coal in the Main Quarry.

2) Edison shall operate a leachate collection and management system at the Joliet/Lincoln Quarry Site that assures compliance with effluent limitations contained in an NPDES permit duly issued by the Illinois Environmental Protection Agency. The leachate collection and management system shall consist of:

a) A gravity flow drainage system that:

i) Channels supernatant liquid from the Main Quarry into the North Quarry; and

ii) Assures that the water level in the Main Quarry is maintained below the natural water table level.

b) A permitted point source discharge from the North Quarry to the Des Plaines River.

3) Groundwater Sampling.

a) Edison shall analyze groundwater from the monitoring well system at the Joliet/Lincoln Quarry Site, in accordance with the requirements of 35 Ill. Adm. Code 811.319(a)(1), for the following constituents:

Ammonia	Fluoride	Selenium	Total Organic Carbon
Arsenic	Manganese	Sodium	Zinc
Boron	Molybdenum	Sulfate	
Cadmium	pH	Total Dissolved Solids	
Chloride	Potassium		

b) Except for the constituents monitored in accordance with a), Edison shall sample its monitoring well system on an annual basis for all inorganic constituents for which the Board has established Class II groundwater standards under 35 Ill. Adm. Code 620.420(a).

i) If Edison detects, and confirms through replicate sampling, a statistically significant increase above applicable groundwater standards for any constituent monitored under this paragraph, Edison shall monitor that constituent in accordance with the requirements of paragraph a).

ii) If, after monitoring for five years in accordance with this paragraph, Edison does not detect a statistically significant increase above applicable groundwater standards for a constituent monitored under this paragraph

2), Edison may propose as a permit modification to discontinue monitoring for that constituent.

4) Waste Sampling.

a) At least once annually, Edison shall determine the semi-volatile organic constituent content of a representative sample of waste bottom ash and slag to be disposed at the Joliet/Lincoln Quarry Site.

b) The results of such sampling shall be submitted to the Agency within 30 days after Edison receives the analytical report.

c) If Edison detects one of the semi-volatile organic constituents listed under 35 Ill. Adm. Code 811.319(a)(3) in its ash samples, then Edison shall conduct confirmatory sampling and analysis.

d) If the sampling and analysis conducted under c) above confirms the presence of one or more of the listed semi-volatile organic constituents, then Edison shall monitor its groundwater monitoring well system for those constituents in accordance with the sampling and analysis plan contained in Volume II of Edison's Application for Significant permit Modification at Lincoln/Joliet Quarry Ash Landfill [IL 197809001] (May 1994).

5) Standards for Monitoring Well Locations.

a) In consultation with Edison, the Agency shall establish a monitoring well network for the Lincoln Quarry Site that achieves the monitoring objectives of part 811. The Agency shall not impose more stringent well location standards than the requirements in 35 Ill. Adm. Code 811.318(b).

b) If any of the wells in the monitoring network established by the Agency fails or is rendered unusable, Edison shall request permission from the Illinois Environmental Protection Agency to replace the well with another well, located as close as practicable to the non-functioning well and sampling the same aquifer.

6) Zone of Attenuation.

a) For purposes of this paragraph f), the zone of attenuation at the Joliet/Lincoln Quarry Site shall be defined as the volume bounded by a vertical plane extending from the ground surface to the bottom of the uppermost aquifer, excluding the waste, and located:

i) 100 feet from the edge of Lincoln Quarry on the upgradient side with respect to groundwater flow; and,

ii) At the property boundary on the downgradient side with respect to groundwater flow. If the property boundary extends beyond the annual high water mark of the Des Plaines River at any location, the zone of attenuation at that location will be reduced to satisfy the requirements of 35 Ill. Adm. Code 811.320(c)(2).

This zone of attenuation is depicted on [Figure SAP-5, Volume II of Edison's Application for Significant Permit Modification, attached to Edison's petition for site specific relief.]

b) Groundwater quality at or beyond the zone of attenuation for the Joliet/Lincoln Quarry Site shall be maintained at each constituent's background concentration.

c) Nothing herein shall be construed to prohibit Edison from petitioning the Board for an adjustment of the groundwater quality standards applicable to the Site, in accordance with the procedures established in 35 Ill. Adm. Code 811.320(b).

d) Compliance Determination.

Any statistically significant increase above an applicable groundwater quality standard that is attributable to the facility and which occurs at or beyond the zone of attenuation within 100 years after closure of the last unit accepting waste within such a facility shall constitute a violation.

7) Final Cover.

a) For purposes of b) and c) below, "maximum adjusted seasonal water table level" means the maximum predicted water table level in the vicinity of the Joliet/Lincoln Quarry Site, determined at the time of closure, plus sufficient elevation to ensure the integrity of a cap.

b) Closure Below Water Table.

i) If, at the time of closure, the level of settled ash in Lincoln Quarry is at or below the maximum adjusted seasonal water table level, no final cover is required for the Quarry and the Quarry shall be maintained as an impoundment.

ii) Water levels in the Quarry shall be maintained at or below a maximum elevation of 570 feet above sea level.

iii) A chain link fence no less than eight (8) feet in height, topped by a no less than three (3) strands of barbed wire, shall be installed around the

Joliet/Lincoln Quarry Site to prevent access and shall be maintained in good condition at all times.

c) Closure Above Water Table.

i) If, at the time of closure, the level of settled ash in Lincoln Quarry is above the maximum adjusted seasonal water table level, Edison shall install a two-stage cover system, which shall consist of a compacted clay layer that performs equivalently to a 2 foot layer of compacted soil having a hydraulic conductivity of 1 x 10^{-7} cm/sec, overlain by at least four inches of topsoil. The cap shall be graded at no less than 2% grade and shall drain to a collection area located on the cap. Stormwater collecting on the cap shall be pumped to the North Quarry for settling prior to discharge pursuant to the facility's NPDES permit. The cap shall be seeded to prevent erosion.

ii) Water levels in the Main Quarry shall be maintained at no more than 570 feet above sea level through use of a gravel drainage blanket underlying the stormwater collection area. Water collecting in the drainage blanket shall drain by gravity to the North Quarry for settling prior to discharge pursuant to the facility's NPDES permit.

Section 41 of the Environmental Protection Act (415 ILCS 5/41 (1994)) provides for the appeal of final Board orders within 35 days of the date of service of this order. The Rules of the Supreme Court of Illinois establish filing requirements. (See also 35 Ill. Adm. Code 101.246 "Motions for Reconsideration".)

IT IS SO ORDERED.

Board Member McFawn Concurred.

I, Dorothy M. Gunn, Clerk of the Illinois Pollution Control Board, hereby certify that the above opinion and order was adopted on the _____ day of ___________, 1996, by a vote of ______________.

____
Dorothy M. Gunn, Clerk
Illinois Pollution Control Board

ILLINOIS POLLUTION CONTROL BOARD
August 15, 1996

IN MATTER OF:	)	
	)	
PETITION OF COMMONWEALTH	)	AS 96-9
EDISON COMPANY FOR AN ADJUSTED	)	(Adjusted Standard - Land)
STANDARD FROM 35 ILL. ADM. CODE	)	
PARTS 811 and 814	)	

CONCURRING OPINION (by M. McFawn):

I agree with the judgment of the majority today that Commonwealth Edison (Edison) is entitled to all the relief requested in its petition. However, I concur because I believe that the relief granted from the regulations listed in Attachment A to Edison's petition should have been included within the terms of the adjusted standard, and that it is inappropriate for the Board to merely state that those requirements do not apply.

The Board has in past cases issued judgments finding that site-specific relief was not warranted because a regulation by its terms was inapplicable to a particular facility. However, this is not the situation in the present case. By their terms, the Attachment A regulations do apply to Edison's facility. Therefore, the more appropriate means of granting relief would have been to have specifically included an adjustment from the Attachment A regulations within the terms of the adjusted standard.

For these reasons, I concur.

____
Marili McFawn
Board Member

I, Dorothy M. Gunn, Clerk of the Illinois Pollution Control Board, hereby certify that the above concurring opinion was submitted on the _____ day of ___________, 1996.

____
Dorothy M. Gunn, Clerk
Illinois Pollution Control Board

EXHIBIT 2

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:

PETITION OF MIDWEST GENERATION FOR AN ADJUSTED STANDARD UNDER 35 ILL. ADM. CODE PARTS 811 and 814	**AS 19-** **(Adjusted Standard-RCRA)**

AFFIDAVIT OF RICHARD GNAT

I, Richard Gnat, being first duly sworn on oath, depose and state as follows:

1. I am over the age of 18 years and am a resident of Wisconsin.
2. The information in this Affidavit is based on my personal knowledge in my capacity as hydrogeologist and environmental consultant with KPRG and Associates, Inc. ("KPRG"). In my employment with KPRG, for over ten years, I have had primary responsibility for providing environmental consulting services to Midwest Generation, LLC ("MWGen") relating to the requirements of the landfill permit issued by the Illinois Environmental Protection Agency to the Joliet/Lincoln Quarry in Joliet, Illinois ("Quarry" or "Site"). Based on this work, I have significant experience related to the environmental compliance requirements and operations at the Joliet/Lincoln Quarry Site ("Quarry" or "Site").
3. I am familiar with the terms and conditions of the AS 96-9, *In re* Petition of Commonwealth Edison Company for an Adjusted Standard from 35 Ill. Adm. Code Parts 811 and 814, (Aug. 15, 1996), the Adjusted Standard granted by the Board for a number of sections of 35 Ill. Adm. Code 811 and 814.
4. The configuration of the Quarry is the same as it was in 1996 when the petition for the Adjusted Standard was filed. Water in the Quarry continues to flow through the gravity-flow drainage system, and the water ultimately is discharged pursuant to the Quarry's NPDES permit, No. IL0002216.

5. The natural groundwater flow at the Quarry is from the south to the north and east to west and the groundwater elevation of the surrounding area is higher than the base of the Quarry.
6. With the exception of a southerly groundwater flow component due to the post-1996 groundwater pumping operations at the nearby Vulcan Quarry, the groundwater flow regime at the Quarry in 1996 and today is the same. In response to the development of a southerly groundwater flow component, MWG installed and continues to operate today a groundwater extraction system to maintain the inward groundwater gradient at the Quarry. The groundwater extraction system is unrelated to and hence, has no effect on, the design of the final cover system for the Quarry.
7. Since 1996, MWG has installed additional monitoring wells and conducted detailed groundwater monitoring. The current groundwater monitoring network is more expansive and comprehensive than that originally approved by the Board in AS 96-9.
8. The groundwater monitoring at the Quarry and associated modeling show that the concentrations in the groundwater flowing into and from the Main Quarry do not negatively affect Des Plaines River water quality.
9. Since the cessation of using coal to generate electricity, only groundwater flow discharges into the Quarry which was conservatively estimated in 1996 at 664,400 gallons per day (gpd). Subsequent numerical groundwater flow modeling completed by Midwest Generation as part of a Groundwater Impact Assessment in 2013 estimated the groundwater/recharge influx into the Main Quarry to be approximately 542,900 gpd, which is lower than the conservative 1996 estimate. Since the remainder of the drainage and discharge system operates the same today as in 1996, the estimated percentage of groundwater that drains into the North Quarry via the gravity drain pipe system and that which naturally discharges into the Des Plaines River is relatively unchanged.

Approximately 76% of the total groundwater flow (approximately 412,600 to 505,000 gpd) that enters the Main Quarry discharges through the gravity flow system into the North Main Quarry and reaches the Des Plaines River through the North Main Quarry pumping system under NPDES Permit No. IL0002216. The remaining 24% (approximately 130,300 to 159,400) of the groundwater discharges directly to the Des Plaines River.

10. MWG controls the future use of the groundwater through pumping and the groundwater management zone, which prevents any adverse environmental or health effects.

11. At the request of MWGen, KPRG evaluated a final cover for the Quarry. KPRG's evaluation identified ClosureTurf as a candidate technology for the final cover. ClosureTurf is a new proprietary cover system. This technology was not available at the time of the original Adjusted Standard. It consists of a geomembrane low permeability layer that is covered with synthetic turf and sand instead of using the traditional clay soil layer covered by a vegetative layer. The synthetic turf looks similar to natural grass and is available in green, tan, or a green/tan combination of colors to blend with the surrounding environment and create the appearance of grass. The synthetic turf is specifically designed to grab and hold the underlying sand infill to prevent its migration during rain and wind events. It is specifically designed to stay in place during rain events and does not require vegetation to hold it in place.

12. The ClosureTurf final protective layer consists of synthetic turf with sand infill that completely covers the geomembrane and prevents it from being exposed and degraded by UV radiation, which can break down the geomembrane similar to desiccation affecting a clay low permeability layer. Also, by not having a vegetative layer, there is no concern for root penetration on the geomembrane layer and the maintenance requirements are significantly reduced.

13. The low permeability layer in the ClosureTurf cover system is a geomembrane that has the permeability of $1x10^{-13}$ cm/s. The permeability of the geomembrane was determined from research conducted by CTT Group, the report attached as Ex. 9.
14. The ClosureTurf synthetic turf and ballast sand infill allow stormwater to pass through them onto the surface of the geomembrane, which is designed to transport stormwater to the drainage system to the North Quarry.
15. The ClosureTurf would cover the Main Quarry, an area of approximately 43 acres. It would tie into the east slope of the West Fill Area, within the property limits of Quarry, for a total final cover surface area of approximately 47 acres.
16. The total cost for the installation of the ClosureTurf would be approximately $8,900,000.
17. The post-closure care for the ClosureTurf for the 30 years of post-closure activities would be approximately $5,220,000.
18. For a soil cover pursuant to 35 Ill. Adm. Code 811.314, the Main Quarry would require 250,250 cubic yards ("CY") of clay, and an additional 250,250 CY of soil for the final protective layer over 47 acres.
19. MWG does not have an onsite borrow source for the soil required for final cover.
20. Bringing a total quantity of 500,500 CY of soil to the site would require approximately 33,367 trucks based on 15 CY per truck. The total cost for purchase and transport of the soil required for the soil layers would be approximately $13,000,000.
21. For a geomembrane cover, with a soil protective cover, the total cost for a geomembrane low permeability layer and a three-foot soil protective layer and the delivery of such material, would be approximately $10,300,000. This includes approximately $3,100,000 for the geomembrane, $6,900,000 for the soil protective layer and the remainder for surface water drainage channel construction.

22. Under the AS 96-9, MWG would install a 2-foot low permeability layer and a 4-inch protective layer, which would require approximately 167,000 CY of clay, and an additional 28,000 CY of soil for the final protective layer.

23. The total approximate cost for the final cover under AS 96-9 would be approximately $6,100,000 based on the original cost from 1994 updated to 2018 costs.

24. The post-closure requirements for the generally applicable final cover and the final cover in AS 96-9 both include mowing the grass cover, annual inspections, and conducting any necessary maintenance and repairs to the vegetative cover or the drainage channels.

25. The annual cost for the post-closure care for both of these types of final cover would be approximately $277,000 per year for 30 years of post-closure activities, totaling $8,310,000.

26. Complete removal of all the CCR from the Quarry would require the removal and offsite disposal of an estimated 2,600,000 CY of ash material.

27. The cost for just the excavation of the CCR alone is estimated at $38,400,000 based on the original 1994 cost updated to 2018 costs.

28. Disposal of all the CCR from Main Quarry would cost in excess of $230,000,000 based on updating the original 1994 cost to 2018 costs and would require approximately 149,700 truckloads to remove the CCR from the Site.

29. Calculations prepared at my direction, showed that delivery and installation of the ClosureTurf system, compared to the generally applicable regulation, would decrease the total carbon emissions and $PM_{2.5}$ emissions by 65%.

30. The Technical Memorandum, attached as Exhibit 4 to the Petition, provides a technical evaluation of the ClosureTurf System. I assisted in and oversaw the preparation of the Technical Memorandum.

31. The Technical Memorandum details use and approval of the ClosureTurf at landfills in other States. Additionally, the Technical Memorandum describes the factors considered in review and approval of the use of ClosureTurf, including its longevity, durability, ease of accessibility and replacement, and effectiveness of the final protective layer for stormwater management.
32. Exhibit 9 is a true and accurate copy of the Geosynthetic Institute White Paper #28 "Cold Temperature and Free-Thaw Cycling Behavior of Geomembranes and Their Seams", June 17, 2013.
33. Exhibit 10 is a true and accurate copy of the CTT Group Analysis Report, April 18, 2017.
34. Exhibit 11 is a true and accurate copy of the Watershed Geosynthetics, LLC letter to Geotechnology, Inc. regarding the Meredosia IEPA Comment on ClosureTurf, Dec. 12, 2016.
35. Exhibit 12 is a true and accurate copy of the Closure Turf LLC – Landfill Cover Systems Retained Tensile Strength v. Weathering Time, New River, Arizona.
36. Exhibit 13 is a true and accurate copy of the Georgia Institute of Technology, "Aerodynamic Evaluations of Closure Turf Ground Cover Materials", May 14 – July 8, 2010.
37. Exhibit 14 is a true and accurate copy of the R. Koerner, Y. Hsuan, G. Koerner, "Geomembrane Lifetime Prediction: Unexposed and Exposed Conditions", Geosynthetic Institute White Paper #6, June 7, 2005, updated February 8, 2011.
38. Exhibit 15 is a true and accurate copy of the Letter to Jose Urrutia, ClosureTurf, LLC from Zehong Yuan, Laboratory Manager, SGI Testing Services on July 8, 2010 on "Evaluation of Drivability Light Weight Construction Equipment on Closure Turf Cover System"

39. Exhibit 16 is a true and accurate copy of the TRI/Environmental, Inc. Erosion Testing Report, April 26, 2010.

40. Exhibit 17 is a true and accurate copy of the Watershed Geosynthetics, LLC, "Summary of Benefits of ClosureTurf", undated.

41. Exhibit 18 is a true and accurate copy of the TRI/Environmental, Inc., Project: ASTM D6459, Client ClosureTurf, July 20, 2015.

42. Exhibit 19 is a true and accurate copy of Watershed Geosynthetics, LLC, "Design Life of ClosureTurf", undated.

43. Exhibit 20 is a true and accurate copy of the TRI/Environmental, Inc. Project: ClosureTurf with Sand-Cement Infill-Channel Lining, July 20, 2015.

44. Exhibit 21 is a true and accurate copy of the Letter to Jose Urrutia, ClosureTurf, LLC from Zehong Yuan, Laboratory Manager, SGI Testing Services on June 27, 2010 on "Laboratory Test Results Transmittal Interface Direct Shear Testing Closure Turf Cover System"

Under penalties as provided by law pursuant to Section 1-109 of the Code of Civil Procedure, the undersigned certifies that the statements set forth in this instrument are true and correct, except as to matters therein stated to be on information and belief and as to such matters the undersigned certifies as aforesaid that he verily believes the same to be true.

FURTHER AFFIANT SAYETH NOT.

Richard R. Gnat

Richard Gnat

Subscribed and Sworn to before me
on Feb 5, 2019

Judith A. McCaigue

Notary Public

JUDITH A MCCAIGUE
Notary Public
State of Wisconsin

My Commission Expires: 4-7-2021

EXHIBIT 3

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:

PETITION OF MIDWEST GENERATION FOR AN ADJUSTED STANDARD UNDER 35 ILL. ADM. CODE PARTS 811 and 814	**AS 19-** **(Adjusted Standard-RCRA)**

AFFIDAVIT OF WILLIAM NAGLOSKY

I, William Naglosky, being first duly sworn on oath, depose and state as follows:

1. I am over the age of 18 years and am a resident of Illinois.
2. The information in this Affidavit is based on my personal knowledge or belief in my capacity as Plant Manager of Joliet 9 and 29 Generating Stations, including the Joliet/Lincoln Quarry in Joliet, Illinois ("Quarry" or "Site"), and I would testify to such matters if called as a witness.
3. The Quarry is approximately 100 acres in size and is located south of the Des Plaines River at the corner of Brandon Road and Patterson Road in unincorporated Will County, south of Joliet, Illinois. Since Midwest Generation, LLC ("MWGen") has operated the Quarry, MWGen has used the Site for the disposal of Coal Combustion Residuals ("CCR") from the Joliet 9 and Joliet 29 electric generating stations, which are located in close proximity to the Quarry.
4. Joliet 9 and Joliet 29 electric generating stations employ 47 people.
5. The Quarry site consists of three main areas: the North Quarry settling pond; the West Filled Area; and, the Main Quarry. The West Filled Area is closed, with a vegetative cover. The CCR placed in the Main Quarry consists only of bottom ash. The North

Quarry settling pond acts as a "polishing step" for the Main Quarry water prior to its discharge to the Des Plaines River under NPDES Permit No. IL0002216.

6. Based on documentation reviewed and under information and belief, since 1996, the Quarry has operated in the same manner as it operated at the time of the 1996 Petition, and bottom ash and slag were placed in the Quarry and the constituents of the ash remain the same.

7. In 2016, the Joliet 9 and 29 generating stations were converted to burning natural gas for fuel. Since their conversion to natural gas, the stations no longer generate CCR and only bottom ash and slag from the cleanout associated with the conversion and closure of residual ash ponds at Joliet 29 station has been disposed in the Quarry. Once the Joliet 29 ash ponds are empty, no additional materials will be disposed of in the Quarry.

Under penalties as provided by law pursuant to Section 1-109 of the Code of Civil Procedure, the undersigned certifies that the statements set forth in this instrument are true and correct, except as to matters therein stated to be on information and belief and as to such matters the undersigned certifies as aforesaid that he verily believes the same to be true.

FURTHER AFFIANT SAYETH NOT.

William Naglosky

William Naglosky

Subscribed and Sworn to before me
On January 27th, 2019.

Michael Murphy

Notary Public

My Commission Expires: 6.27.2022

"OFFICIAL SEAL"
Michael Murphy
Notary Public, State of Illinois
My Commission Expires 06/27/2022

EXHIBIT 4

K P R G

ENVIRONMENTAL CONSULTATION & REMEDIATION

KPRG and Associates, Inc.

Technical Memorandum In Support of Midwest Generation, LLC's Petition for an Adjusted Standard

The ClosureTurf final cover system is equivalent or superior to a traditional subtitle D landfill and Illinois' requirements. The benefits of ClosureTurf include reduced installation and maintenance time, reduced long-term maintenance costs, and construction related environmental impacts. ClosureTurf has been approved for use as a landfill final cover in 18 states: Delaware, Florida, Georgia, Illinois, Louisiana, Massachusetts, Minnesota, Missouri, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, and Washington. The ClosureTurf installation in Illinois was performed in Meredosia, IL for a coal combustion residual (CCR) pond that was being closed by Ameren Energy. This installation was approved by Illinois Environmental Protection Agency (IEPA). This Technical Memorandum details the other locations in which a State approved ClosureTurf as the final cover for a landfill. Additionally, this Memorandum identifies the State Regulatory Agency comments and questions regarding ClosureTurf and the answers for same.

I. *Select ClosureTurf Approval Precedencies*

IEPA approved the use of ClosureTurf as a final cover system as part of the closure of two CCR surface impoundments in Meredosia, IL. The surface impoundments were used as fly ash and bottom ash ponds for the Ameren Energy Medina Valley Cogen, LLC Meredosia Power Station (Ameren Energy). The closure consisted of consolidating most of the bottom ash into the fly ash pond and then closing-in-place the fly ash pond, which is about 35 acres and a portion of the bottom ash pond, which was about 2 acres. The fly ash and bottom ash consolidation was then closed-in-place using ClosureTurf. A closure plan, dated August 15, 2016, was originally submitted by Ameren Energy to IEPA's Bureau of Water, Groundwater Section for review and approval. IEPA reviewed the closure plan and provided comments to Ameren Energy's consultant, who revised the closure plan and provided responses, dated February 6, 2017 to IEPA. The revised closure plan with supplemental data and responses was approved by the Groundwater Section of the Bureau of Water in a letter dated March 8, 2017 and signed by William Buscher.

The comment from IEPA that discussed ClosureTurf was in related to a disclaimer that Watershed Geo has as part of their ClosureTurf Installation Guidelines Manual. As part of the responses to IEPA's comments, Watershed Geo provided a letter on Ameren Energy's behalf that states that using ClosureTurf as a final cover system to contain CCR is its intended purpose. The letter clarifies that the disclaimer is intended to limit Watershed Geo's liability related to conditions and activities beyond their direct control. A copy of that letter is included as Ex. 11.

The MassDEP approved the use of ClosureTurf as an alternative final cover system on approximately 4 acres of an approved final cover system through a permit modification.

ClosureTurf was installed in 2014 as a final cover at the Carver-Marion-Wareham Landfill, which is a waste to energy CCR landfill. As part of the permitting process and in accordance with MassDEP regulations, the applicants submitted an equivalency review that demonstrates how ClosureTurf complies with the final cover requirements. The equivalency review successfully demonstrated that ClosureTurf was equivalent or superior to the requirements for the following:

- Low permeability layer,
- Drainage layer,
- Filter material standards,
- Minimization of erosion,
- Installation of the ClosureTurf using low ground pressure equipment that won't damage the geomembrane,
- Observing the potential effects of waste settlement and a simpler repair process of settle areas,

It was noted as part of the MassDEP approval, that ClosureTurf uses less material than a traditional cover system, which saves natural resources and reduces emissions because less material is being transported to the construction site. This is also true for the Lincoln Stone Quarry ("LSQ") as presented in the petition for Adjusted Standard. In addition, the post-closure costs are reduced for ClosureTurf compared to a traditional soil cover.

The MassDEP modification approval referenced the third-party independent testing that has been performed on ClosureTurf. These references were used as a means of demonstrating how the ClosureTurf cover system was equivalent or superior to the Massachusetts landfill regulations for final covers. This was particularly true when the permit discussed the equivalency regarding drainage and how stormwater would affect the ClosureTurf. The third-party testing demonstrated that the accepted ClosureTurf design would not succumb to shear failure on the proposed slopes and even under saturated conditions the interface friction angle was sufficient to prevent shear failure on the proposed slopes. This same third-party testing is presented in the previous sections for slope stability.

The MassDEP permit approval also referenced third party testing that has been referenced in this Adjusted Standard petition regarding the durability of ClosureTurf during wind and rain events. As described in detail below, ClosureTurf was tested against wind speeds up to 120 mph and minimal uplift was observed on the synthetic turf. The minimal uplift was observed on the perimeter of the synthetic turf, with no uplift observed on the interior portion of the synthetic turf. The interior was determined as being 18" away from the perimeter of the turf on the testing apparatus. ClosureTurf was tested against a four inch/hour (in/hr) rain intensity to determine the critical slope lengths that the system can achieve without inundating the sand infill, which could cause erosion of the sand infill. This testing was accepted by MassDEP for justification of the ClosureTurf design presented by the applicant. This same testing and method for calculating the critical slope lengths for ClosureTurf was used as part of the ClosureTurf design for LSQ. The shape and slopes of the regraded CCR in LSQ were designed to avoid exceeding any critical slope lengths.

The durability of the synthetic turf blades were also discussed as part of MassDEP's approval. Testing being conducted by Watershed Geosynthetics and a third-party testing service has determined that after 50 years the tensile strength of the synthetic turf fibers are still twice the minimum amount required to resist the pullout force of vehicle traffic and stormwater runoff. The research has concluded that even after 100 years the synthetic turf fibers will still have tensile strength above the minimum necessary.

The same comments discussed above as part of the Massachusetts approval were also addressed as part of the ClosureTurf approval in South Carolina.

The South Carolina Department of Health and Environmental Control (SCDHEC) approved the use of ClosureTurf as a final cover system for the Berkeley County municipal solid waste landfill. The Berkeley County Landfill is an active municipal solid waste landfill that began operating in 1999. ClosureTurf was the cover system of choice for the Berkeley officials when four of the eight cells at the landfill reached capacity and were ready to be closed. Closing the landfill involved challenges because the waste had been built too far to the edge of the cells, the landfill is located in an earthquake zone and the area is susceptible to hurricanes and high rainfall events. There was concern that during a significant rain event a slide hazard would develop if a traditional soil cover was used. The Berkeley County officials worked closely with the SCDHEC and the ClosureTurf construction was approved and completed in January 2014.

As part of the permitting process, the SCDHEC had questions regarding the longevity of ClosureTurf, the cost benefit over a traditional soil cover, stormwater runoff conditions, and accessibility to areas of the cover. Other issues raised by SCDHEC included the durability of ClosureTurf, slope stability, the condition of it during post-closure, settlement and ponding, and replacing ClosureTurf (if necessary). Berkeley County Landfill officials, their consultant engineer, and Watershed Geo made several presentations to SCDHEC to address the questions and issues that were raised. Third party testing has been done that demonstrates that ClosureTurf is durable enough to withstand rubber-tired vehicle traffic, is resistant to shear failure and sliding because its high interface friction between the synthetic turf and geomembrane, and is resistant to erosion because the synthetic turf fibers are designed to hold the sand infill in place during rain events. Third party weathering testing conducted in New River, AZ demonstrated that the synthetic turf of ClosureTurf was UV resistant with a design life of 100 plus years. Based on this information, ClosureTurf was approved and installed at the landfill.

As a condition of approval, SCDHEC required ClosureTurf to be inspected frequently during the first two years of installation. Those inspections have been completed and ClosureTurf successfully passed all the inspections. As reported by Bob Buzzell, Field Operations manager for Watershed Geo, "Other than a few small synthetic turf repairs, the site has withstood environmental and weather conditions extremely well." The synthetic turf is easily inspected because it is not covered with a thick soil profile, and thus is easy and inexpensive to access and repair.

ClosureTurf final cover demonstrated exemplary stability during a flash flooding event at the Berkeley County Landfill in South Carolina. The area received 26 inches of rain over a couple day period. With ClosureTurf, there was enough coverage of infill ballast sand intact that sand did not have to be redistributed or replaced. Conversely, many nearby traditional soil-capped landfills were left with significant and costly erosion. ClosureTurf was able to minimize erosion due to the presence and consistency of the synthetic turf layer and its ability to stabilize the ballast sand. Traditional final cover systems are more vulnerable to erosion due to variations in the growth of the vegetative cover, which stabilizes the cover soils.

II. *Responses To State Regulatory Comments and Questions Regarding ClosureTurf*

In general, when reviewing the proposed ClosureTurf, state regulators had questions about how the performance and functionality of ClosureTurf applied to the specific site where it will be used. A list of the comments and questions compiled during the research is as follows:

- Durability of closure turf
- Longevity of material
- Accessibility to areas of the cap without damaging ClosureTurf
- Replacement of ClosureTurf
- Condition of ClosureTurf during post-closure period
- Weather conditions (effects of freeze-thaw conditions & UV)
- Effectiveness of sand broadcast on ClosureTurf
- Runoff conditions and adequacy of stormwater management system
- Settlement and ponding
- Biological Concerns (mold and mildew)
- Slope stability

The above comments and questions are addressed in the following paragraphs.

a. Durability of ClosureTurf

The durability of ClosureTurf has been evaluated based on retained tensile strength after UV exposure, its performance during wind and storm events, and its drivability. The durability of the ClosureTurf system is based on the strength and UV resistant ability of the engineered synthetic turf. The turf is constructed of two parts. The first part is a double layer of UV-enhanced woven geotextiles and the second part includes polyethylene fibers that are tufted into the geotextiles. The fibers are designed to keep the sand infill embedded between them and prevent the sand's movement from precipitation and wind erosion. As long as the sand infill remains embedded, the turf will remain on top of the geomembrane, and the geomembrane will be protected. Only 3 pounds per fiber tensile strength is necessary to ensure the sand infill remains in place and each fiber has a tensile strength of 35 pounds, which is more than ten times the necessary strength required. Even after 100 years of UV exposure, the necessary strength is retained. (Ex. 19).

The durability of ClosureTurf also coincides with its longevity because the strength of geomembranes and geotextiles are evaluated for how long they retain their strength. The tensile strength of the engineered synthetic turf at the site of the original ClosureTurf installation was tested and those results were compared to UV testing performed in the desert of New River, Arizona. (Ex. 12). The original ClosureTurf installation was at the

LaSalle-Grant Landfill in Jena, Louisiana in 2009. The fibers from the turf at LaSalle Landfill retained 84.2% of their tensile strength after 7 years of exposure on a south facing slope. The south facing slope is the exposure that will get the most sun and the most UV radiation. These results are in line with the results of UV weather testing performed in Arizona that showed the retained tensile strength of turf fibers were 83.8% after 7 years of southern exposure. The synthetic turf will be able to retain its strength well beyond the 30-year post closure period because the intensity of the sun in Joliet, IL is less than what it is in Arizona.

The Georgia Tech Research Institute (GTRI) performed a study on ClosureTurf by exposing it to hurricane force winds. (Ex. 13). The engineered synthetic turf was successfully tested against wind speeds of up to 120 miles per hour (mph) and the test demonstrated that as the wind speed increased so did the downward force exerted on the closure turf, with very small uplift effect (less than 0.13 pounds per square foot) observed on the turf (GTRI), 2010). The greatest amount of the uplift was observed along the perimeter of the ClosureTurf tested, with virtually no uplift effect observed on the interior portion of the ClosureTurf tested. The features of ClosureTurf cause a resistance to the uplift forces from the wind. These features are the porous synthetic turf that breaks the vacuum and lessens the drag surface area, the sand infill that acts as a ballast to keep the turf in place, and the turf fibers that bend and react against the wind. This means that ClosureTurf will be able to withstand the strongest winds at LSQ without experiencing any uplifting because the highest recorded wind gust in Chicago, IL was 87 mph.

The durability of ClosureTurf was also evaluated based on vehicle traffic driving on it. The drivability of ClosureTurf was evaluated based on different subgrade soil types and vehicle weights. The evaluations determined that rubber-tired vehicles could travel over ClosureTurf without causing damage. A vehicle weight of 8,000 pounds and a slope angle of 18 degrees could drive on ClosureTurf without causing shear failure between the ClosureTurf components. The ClosureTurf is durable enough to withstand rubber-tired vehicle traffic ranging from 8,000 lbs to 44,000 lbs. For vehicle weights of 44,000 lbs, the number of passes over the ClosureTurf are expected to be minimal, for example, access by a fire truck or other large emergency vehicle. The ClosureTurf puncture resistance was based on a range of the potential subgrade stone size and the maximum allowable equipment ground pressure. Based on a subgrade stone size of 0.25 to 1.5 inches, the maximum allowable equipment ground pressure was about 400 psi to 20 psi, respectively. In the case of LSQ, a particle size analysis of the CCR material determined that 97% of it passed the 3/8” sieve size (0.375 inches), which means that the allowable equipment ground pressure will be closer to 400 psi than it will be to 20 psi. Based on this, the subgrade soil and the ClosureTurf will be able to withstand vehicle traffic from a fire truck or a vehicle of equivalent weight if it ever needed to access the cover.

b. <u>Longevity of Material</u>

The turf looks similar to natural grass and is available in green, tan, or a green/tan combination of colors to blend with the surrounding environment and create the appearance of grass. The turf is made resistant to extreme weather, long-term UV degradation, and heat. The turf has been tested using an independent UV weather study performed in New River, Arizona that utilized accelerated extreme exposure conditions that indicated the engineered turf will still retain at least 50% of its tensile strength (half-life) after 100 years of UV exposure (Watershed, 2014). In addition, an independent literature review performed on behalf of Watershed Geo identified other documents that predicted geomembranes exposed to UV degradation retained 50% of its tensile strength after approximately 100 years of exposure.

The Geosynthetic Institute (GSI) has conducted research on the lifetime predictability of geomembrane, particularly high-density polyethylene (HDPE). (Ex. 14). The lifetime of a geomembrane is based on whether it is covered or exposed to the environment, the formulation of the geomembrane, and the degradation mechanisms the geomembrane might be exposed to. Some of the degradation mechanisms that might occur are ultraviolet light, oxidation, ozone, hydrolysis, chemical, radioactivity, biological, stress, and temperature. The studies of the lifetime prediction have been conducted mostly on HDPE geomembranes placed beneath solid waste landfills because of their common use in this application. The research has identified three lifetime stages for HDPE geomembrane that are 1) antioxidant depletion time, 2) induction time to the onset of degradation, and 3) time to reach 50% degradation of the geomembrane.

Antioxidant depletion time is the time it takes for the antioxidants in the geomembrane to be depleted from the geomembrane. Antioxidants are used in geomembranes to prevent the polymer from degrading during the geomembrane processing and to prevent oxidation reactions from taking place that would degrade the geomembrane. Antioxidants in the geomembrane react with the surrounding environment and these reactions deplete them from the geomembrane. The rate at which this occurs depends on the amount of antioxidants in the geomembrane, the temperature of the surrounding environment, and the nature of the surrounding environment.

Induction time to the onset of degradation is the beginning stages of oxidation in a geomembrane. The induction time occurs at the beginning of the oxidation process where the polymers in the geomembrane are reacting with oxygen in the surrounding environment and occurs very slowly. During this stage, the degradation of the geomembrane is considered immeasurable. As the oxidation continues the process occurs more rapidly and at this point the induction time, or induction stage, is considered over and the oxidation process has moved passed the induction time and into the later stages of oxidation.

The later stages of oxidation produce free radicals, which degrade the geomembrane. The degradation that occurs affects the physical and mechanical properties of the geomembrane, specifically, the tensile strength and the elongation ability decrease. Ultimately, the strength properties of the geomembrane will be degraded at which point the engineering performance is compromised. The compromising of the engineering performance of the geomembrane is considered the end of its service life. The geosynthetics industry has designated the end of service life when a design property has reached 50% of its original value. For example, when a geomembrane has reached 50% of its original tensile strength based on the manufacturer’s quality control testing than the geomembrane has reached the end of its service life. It should be noted that the geomembrane exists and is still useable, but the performance of it will be diminished.

GSI compiled the research and data on the above-described stages to predict the total lifetime of different types of geomembranes. In the case of LSQ, the MicroDrain geomembrane used in ClosureTurf will be covered and is a HDPE geomembrane experiencing spring and summer temperatures ranging from 50 degrees Fahrenheit (deg. F) to 95 deg. F. The above-discussed research has determined that the predicted lifetime of the ClosureTurf geomembrane for LSQ is between 106 years to 446 years based on service temperatures ranging from 68 deg. F to 95 deg. F, respectively. The lowest discussed service temperature for geomembranes in 68 deg. F. In the case of geomembrane degradation, the higher the temperature the more rapid the degradation. As a result, the winter temperatures will not affect the degradation of the geomembrane. This means the geomembrane will last longer in Joliet, IL than it would in Arizona.

c. Accessibility To Areas of The Cap Without Damaging ClosureTurf

Accessibility to the ClosureTurf cover for maintenance at the LSQ will initially be accomplished through an access road. The access road will be constructed to enter the Main Quarry from the west side of LSQ and travel along the slope of the WFA heading south. At this point, the access road will turn east towards the northeast corner of the Main Quarry. Rubber-tired vehicles are able to drive on the ClosureTurf cover system without damaging the turf and geomembrane based on the weight and frequency with which the driving occurs. Drivability studies were performed on the ClosureTurf system for potential sliding (shear failure), bearing capacity of the subgrade soil, and puncture resistance. Those studies are discussed below.

The maintenance traffic that is anticipated to access the ClosureTurf cover is mainly non-construction passenger vehicles during inspections. The drivability of the ClosureTurf post-construction was evaluated for potential sliding (shear failure) between the ClosureTurf components by SGI Testing Services, LLC (SGI). (Ex. 15). The post-construction ClosureTurf cover system from bottom to top consisted of compacted subgrade soil, 50-mil LLDPE Super Gripnet, synthetic turf and approximately one inch of sand infill. The vehicle traffic was based upon rubber-tired construction equipment (RTCE) with a weight of approximately 8,000 pounds (lbs) and the load of the RTCE evenly distributed between four tires. The potential sliding was evaluated using the peak friction angle between the sand/synthetic turf and the Super Gripnet geomembrane. The analysis determined that with a peak friction angle of 34 degrees and a manufacturer’s recommended maximum slope angle of 18 degrees the factor of safety of 2.0 was determined for the shear failure between the tire and sand/turf contact area. The factor of safety of 2.0 determined above is greater than the minimum required static factor of safety of 1.5 (811.205(a)). Therefore, an 8,000 pound, rubber-wheeled vehicle will not cause shear failure between ClosureTurf components on a slope less than 18%. The maximum slope that occurs in the regraded Main Quarry is 15% with an average slope of 7-8%. For example, a Chevrolet Silverado 1500 Z71 with a full payload weighs about 7,200 lbs. A fully loaded pickup truck of this size may be used during the routine inspections of the ClosureTurf.

The bearing capacity of ClosureTurf was evaluated with two different studies. The first study involved an 8,000 lbs RTCE. To determine the worst-case scenario, the bearing capacity was evaluated for soft soil. The previously mentioned drivability study determined that an 8,000 lbs vehicle without limiting the number of passes is able to drive on ClosureTurf without causing any damage.

The second bearing capacity study was conducted using an 80 horsepower (hp) tractor with a weight of about 11,000 lbs and a rural fire truck with a weight of around 44,000 lbs. A weight of 11,000 lbs is equivalent to a 14-psi tire pressure and 44,000 lbs is equivalent to a 55-psi tire pressure. Each tire pressure was evaluated based on 1) a range of compacted soil types, from clay to silty sand, 2) the soil is compacted to 95% of the standard proctor, and 3) the expected number of passes over the ClosureTurf for each vehicle is less than 100. The number of passes over the ClosureTurf was expected to be 100 or less because the tractor is the vehicle that would be expected to assist in distributing the sand infill and/or ArmorFill over the synthetic turf. The soil types based on the Unified Soil Classification System (USCS) ranged from CH, high plasticity clay, to SM, silty sand. The gravel soil type was evaluated as part of this analysis. The analysis determined that the calculated factor of safety ranged from 5.6 to 59.1 for the 11,000 lbs tractor (14 psi tire pressure), which exceeds the minimum factor of safety of 2.0, even if the subgrade soil is soft. The LSQ soil type that the ClosureTurf will be placed on has been classified as SM based on the USCS, which had a factor of safety of 59.1. The fire truck was also evaluated in the event that it would need to access the ClosureTurf and it was necessary to know if the compacted soil and ClosureTurf could support the weight. The analysis determined that the calculated factor of safety ranged from 1.4 to 9.6 for the 44,000 lbs rural fire truck (55 psi tire pressure), which exceeds the minimum factor of safety of 2.0, except for the lowest value of 1.4, which was for high plasticity clay (USCS soil type CH). The LSQ soil type of SM had a factor of safety of 9.6. Based on the above-discussed analyses, the LSQ soil type of SM will have sufficient bearing capacity to support a vehicle weight up to 44,000 lbs. The sufficient bearing capacity of the soil will support the necessary support vehicles as they travel across the ClosureTurf, which will prevent vehicles from puncturing and tearing the turf and geomembrane due to sagging soils.

The drivability of ClosureTurf was also analyzed for puncture resistance. Puncture of a geomembrane occurs either from the overburden soil or from a rocky subgrade below the geomembrane. In the case of ClosureTurf, the puncture resistance was analyzed based on a rocky subgrade below the geomembrane and equipment load above the geomembrane. The analysis was performed based ClosureTurf being placed on a range of stone sizes from 0.25 inches to 1.5 inches in size with a 10 oz/yd^2 geotextile placed between the ClosureTurf and the stone. This range of stones (0.25 inches to 1.5 inches) identified the maximum allowable equipment pressure to be 407 psi to 20.8 psi. In the case of LSQ, no geotextile will be placed between the ClosureTurf and the CCR subgrade, the CCR surface will be proof-rolled with a smooth-drum roller to push any stones into the CCR and protect the geomembrane. Based on this the maximum allowable stone size underneath the ClosureTurf is 0.5 inches with a maximum allowable equipment pressure of 143 psi. In the case of LSQ, a particle size analysis of the CCR material determined that 97% of it passed the 3/8" sieve size (0.375 inches) and 100% passed the 0.5-inch sieve size. The CCR material size is less than 0.5 inches that was determined to be the maximum allowable size with a maximum allowable equipment pressure of 143 psi. In the case of LSQ, the equipment that will be occasionally used on ClosureTurf is expected to have a maximum equipment pressure up to 55 psi, which is less than the maximum allowable pressure of 143 psi.

d. *Replacement of ClosureTurf*

The first ClosureTurf installation occurred in 2009 in Louisiana. Including the first installation, none of the other ClosureTurf installations has had to replace any portions of the ClosureTurf. As of the end of 2017, over 40 million square feet of ClosureTurf had been installed in 18 states around the country. As of the end of 2018, ClosureTurf has been installed in 20 states around the country.

If replacing any portion of ClosureTurf is necessary, the process is easier than replacing portions of a traditional soil cover. If the synthetic turf or geomembrane are damaged, that portion can be cut, removed, and a new piece installed and welded to the remaining existing synthetic turf or geomembrane. If the geomembrane is replaced, the only extra step is to cut and peel back the synthetic turf to expose the geomembrane. In either case, the sand infill should be replaced as needed. Regrading would only be involved during the replacement of ClosureTurf if settling of the subgrade occurred.

Replacing a portion of a traditional soil cover will require more work than replacing a portion of ClosureTurf. Repairing and or replacing a portion of the traditional soil cover will require soil being brought to the site along with construction equipment to grade and compact the soil. Repairing and replacing a damaged portion of a traditional soil cover will require excavating and/or regrading the damaged portion of the cover, followed by adding additional soil, grading that soil and then seeding the soil.

e. *Condition of ClosureTurf During Post-Closure Period*

The condition of the ClosureTurf cover system will not change during the post-closure period. Based on the durability and longevity data presented above, the ClosureTurf will be in the same condition at the end of the 30-year post-closure period as it was the day of its installation. ClosureTurf has been designed and manufactured to last well beyond a typical 30 years of post-closure monitoring.

f. *Weather Conditions (Effects of Freeze-Thaw Conditions & UV)*

The GSI published White Paper #28 (Exhibit 9) that summarized a report released by the U.S. Bureau of Reclamation (USBR) in 1996 that studied the freeze-thaw effect on geomembranes. The USBR report studied the freeze-thaw cycle effect on 19 different geomembrane sheet materials and 31 different seam types, consisting of seven different resin types. The seven different resins included HDPE, which is applicable to the geomembrane that will be used in ClosureTurf. The geomembrane sheets and seam types experienced freeze-thaw cycles at +68 deg. F for 8 hours and then -4 deg. F for 16 hours.

One group of sheets and seams experienced 200 freeze-thaw cycles with tensile (strength) tests being conducted on the sheets and seams after 1, 5, 10, 20, 50, 100, and 200 cycles were completed. The tensile tests were conducted with the sheets and seams at a temperature of +68 deg. F. Another group of sheets and seams also experienced 200 freeze-thaw cycles with tensile (strength) tests being conducted on the sheets and seams after 1, 5, 10, 20, 50, 100, and 200 cycles. In this case, though, the tensile tests were conducted with the sheets and seams at a temperature of -4 deg. F. A third group of sheets and seams experienced 500 freeze-thaw cycles but the sheets and seams were tensioned at a constant strain during the cycling. Tensile tests were performed on this third group after 1, 5, 10, 20, 50, 100, and 200 cycles with the specimens at a temperature of +68 deg. F.

The results of the study for all three groups discussed above concluded the following:

- The tensile tests on the geomembrane sheets "showed no change in the peak strength or peak elongation of any of the tested materials".
- The shear tests on the geomembrane seams "showed no change in shear strength of any of the tested seam materials".
- The peel tests on the geomembrane seams "showed no change in peel strength of any of the tested seam materials".

As quoted from GSI's White Paper #28, "The conclusion that the authors reached is that there is simply "no change" in tensile behavior of geomembrane sheets or their seams after freeze-thaw cycling. It is felt that this conclusion in the context of their study is so impressive that it has essentially "closed the door" to further research on this specific topic." The authors end their white paper by stating that the answer to the question of whether freeze-thaw cycling will affect geomembranes and their seams is "a resounding NO".

In summary, the freeze-thaw cycle the ClosureTurf will experience in Joliet will not impact its performance.

g. *<u>Effectiveness of Sand Broadcast On ClosureTurf</u>*

One of the regulatory questions was regarding the methodology to be used that will assure a consistent infill sand layer thickness over the entire area of synthetic turf. This issue has been successfully dealt with by the development of clear and stringent placement specifications. Based on the developed specifications, a specified infill material will be placed between the blades of the engineered synthetic turf after the turf is in place on top of the geomembrane. The specified infill used at LSQ will be sand. The sand will be placed to a uniform depth of at least 0.5-inches between the blades of the engineered synthetic turf. The sand infill will be a medium particle size sand meeting ASTM C-33 particle size requirements for fine aggregates.

Conveyor systems and/or Express Blowers will be used to spread and place the sand infill and on-site workers will ensure the sand infill is worked into the engineered turf between the polyethylene fibers. The sand infill placement will not occur with snow or ice on the synthetic turf and care will be taken to ensure that previously installed ClosureTurf components are not displaced or damaged during the sand infill installation. Quality control checks of the sand infill thickness will occur at approximately 100-foot grid intervals. This is the same process that was successfully used at other ClosureTurf installations.

h. Runoff Conditions And Adequacy of Stormwater Management System

The geomembranes used in the ClosureTurf system are structured geomembranes that combine a studded drain surface on the top side and spiked friction surface on the bottom side. The studded drain surface creates a drainage system integrated into the geomembrane for the conveyance of stormwater over the entire surface of the geomembrane and replaces the need for a separate drainage layer or stormwater conveyance system, such as drainage swales or channels. The synthetic turf and sand infill allow for stormwater passing through onto the geomembrane. Stormwater flows in the space between the geomembrane and the geotextile layer (approximately 0.125 inches), within the 0.5-inch sand infill layer, and above the sand drainage layer at a maximum design depth of approximately 0.75 inches, for a total maximum head of less than 2 inches. This is superior to a traditional soil cover system because it transports the stormwater runoff and minimizes the head on the geomembrane, which lessens the chance for infiltration. With a traditional soil cover system on a relatively flat top area, stormwater may saturate the final protective layer resulting in a hydraulic head of up to 24-36 inches on the geomembrane. In the case of LSQ, the stormwater runoff on the ClosureTurf final cover system will produce less head on the low permeability geomembrane layer, which reduces any chance for infiltration.

Erosion of the sand infill and subsequent erosion repairs are almost non-existent based on independent testing performed by TRI Environmental, Inc (TRI; Ex. 16). ClosureTurf was tested by TRI in accordance with ASTM 6459 using rainfall intensities of 2, 4, and 6.5 inches per hour (in/hr). *Id.* These rainfall intensities correspond to about a 2-year, 24-hour storm; about a 25-year, 24-hour storm, and about a 100-year, 24-hour storm, respectively, for LSQ's runoff conditions. Sand infill was not identified in the 2 in/hr and 4 in/hr rainfall runoff and only 0.41 lbs of sand infill was identified in the 6.5 in/hr rainfall runoff (100-year, 24-hour storm). The total sand infill quantity used during the test was 1,130 lbs, which equates to a runoff loss of only 0.04%. This minimal erosion of the sand infill demonstrates that ClosureTurf will be superior to meeting the water quality requirements associated with controlling the 25-year, 24-hour storm and even the 100-year, 24-hour storm. ClosureTurf will also reduce the cost and time associated with repairs associated with erosion and improve the water quality of the stormwater runoff.

The cost and time associated with the maintenance of downstream erosion and sediment accumulation is reduced due to the filtration qualities and minimal erosion of the sand infill. Stormwater water quality sampling was performed at Tangipahoa Landfill in Tangipahoa Parrish, LA to compare an area of soil covered with a standard Subtitle D soil cover system and an area of material covered with ClosureTurf. The turbidity of the stormwater runoff from the ClosureTurf area was 97% less compared to the turbidity of the traditional soil cover area (11 NTU vs. 371 NTU, respectively). The total suspended solids (TSS) concentration for the ClosureTurf stormwater runoff was over 99% less than the traditional soil cover stormwater runoff TSS concentration (<4 mg/L vs 349 mg/L, respectively). See Ex. 17.

If necessary, ArmorFill will be placed on the sand infill at the locations where the erosion potential is the greatest. These areas will be the west slope of the Main Quarry, the east slope of the Main Quarry, and the locations where the extraction systems discharge. ArmorFill will also be used over a 100-foot radius around the discharge pipes to prevent any sand infill migration during storm events. ArmorFill is a polymer emulsion based on the sand infill specifically designed to bind the sand infill and prevent its migration during rain events. The ArmorFill will prevent erosion of the sand infill for flow rates up to 16 cubic feet per second (cfs) based on testing performed by TRI in 2015. (Ex. 20). ArmorFill was also tested against different rainfall intensities and only 0.01% of the sand infill was observed in the runoff from a rainfall intensity of 6 in/hr. Erosion testing was performed on the sand infill without ArmorFill, and that testing indicated that 0.04% of the sand infill was observed in the runoff from a rainfall intensity of 6 in/hr. The use of ArmorFill reduces the runoff of the sand infill by 75%. (Ex. 18).

Earthen berms are located on the north, east and south rims of the Main Quarry and serve for both visual screening and partial run-on control. The berms are 3 to 5 feet high and adjoin the shoulders of both Patterson and Brandon Roads, except where gate access is provided. The berms control surface water run-on in these areas, but run-on does occur from local areas just south of the Main Quarry and from the West Filled Area into the Main Quarry. The storage capacity of the Main Quarry is more than enough to handle and control any offsite run-on. All of the water reaching the Main Quarry ultimately is discharged to the Des Plaines River in accordance with Midwest Generation’s NPDES permit. The West Filled Area is graded to drain into the Main Quarry.

i. <u>Settlement and Ponding</u>

The CCR will be compacted to stabilize it prior to placement of the final cover system and to reduce the potential for future settling. Due to the sandy composition of the CCR, most settlement will occur during regrading and compaction. Time dependent settling of the CCR should be insignificant and calculations completed for preparation of this plan indicate that settlement of the final cover is estimated to be about 1 inch.

All the precipitation the enters the Main Quarry will be discharged through the existing discharge pipes that exit the Main Quarry into the North Quarry settling pond. There are two discharge pipes, each one is 20 inches in diameter, and combined they are sized to prevent ponding of stormwater runoff that may be expected during a 100-year, 24-hour storm event.

j. <u>Biological Concerns (Mold & Mildew)</u>

Biological concerns are not expected to be an issue with the ClosureTurf system. The materials used to construct the ClosureTurf geomembrane and synthetic turf are not prone to growing mold or mildew and the sand infill will be aerated due to its particle size, which will prevent mold and mildew growth. The proprietors of ClosureTurf were not aware of biological issues occurring at any of the existing ClosureTurf installations.

k. Slope Stability

The geomembrane will be covered with engineered synthetic turf. The engineered synthetic turf replaces the need for an erosion layer and vegetation while providing a natural look and feel of grass and protecting the geomembrane from extreme weather. The engineered synthetic turf is dimensionally stable, has a high interface friction angle, gives the appearance of grass, is almost maintenance free and is resistant to extreme weather, UV light, and heat. The turf is manufactured to be stable regardless of which direction it is being pulled or moved. Interface direct shear testing performed by SGI in 2010 (Ex. 21), determined that shear failure will occur on the underlying slope before it would occur between the engineered turf and the geomembrane.

Calculations were performed using the proposed slopes that range from 2.2% to 14.7% to evaluate the static safety factor and the seismic safety factor for the final cover system. The factor of safety against slope failure for static loading conditions was determined to range from 2.2 for a slope of 14.7% to 14.7 for a slope of 2.2%, easily exceeding the minimum required static safety factor of 1.5. The factor of safety for dynamic loading conditions ranges from 1.4 to 9.1, which exceeds the minimum required seismic safety factor of 1.3.

The geomembranes used in ClosureTurf are structured geomembranes that combines a studded drain surface on the top side and spiked friction surface on the bottom side. The proprietary geomembrane design developed by AGRU America that will be specified in the LSQ design is called MicroDrain which is constructed of 50 mil HDPE. The studded drain surface creates a drainage system integrated into the geomembrane for the conveyance of stormwater over the entire surface of the geomembrane and replaces the need for a separate drainage layer or stormwater conveyance system, such as drainage swales or channels. The drainage surface design keeps the conveyance of stormwater off the top of the sand infill minimizing the potential of the engineered turf sliding and the sand infill being washed away. The spiked friction surface has spikes spaced in a deliberate pattern that provides an interface friction and a factor of safety against sliding on slopes. The spiked friction surface resists the shear failure that can occur with a traditional soil cover. At LSQ, the slopes were designed in a way as to minimize the potential for shear failure.

EXHIBIT 5

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
PETITION OF COMMONWEALTH EDISON	)	AS. 96-9
COMPANY FOR ADJUSTED STANDARD	)	(Adjusted Standard)
FROM: 35 ILL. ADMIN. CODE 811.814	)	

NOTICE OF FILING

To:

Mary A. Gade
Director
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Judith Dyer
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John Moore
Director
Energy and Natural Resources Department
325 W. Adams
Springfield, Illinois 62704-1892

PLEASE TAKE NOTICE that on April 1, 1996 I have filed with the Office of the Clerk of the Pollution Control Board, State of Illinois Center, Chicago, Illinois, the ADJUSTED STANDARD PETITION of Commonwealth Edison Company, a copy of which is herewith served upon you.

Dated: April 1,1996

By: Marian E. Whiteman
One of the Attorneys for
Commonwealth Edison Company

Alan P. Bielawski
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(312) 853-7000

THIS FILING SUBMITTED ON RECYCLED PAPER

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
PETITION OF COMMONWEALTH EDISON COMPANY FOR ADJUSTED STANDARD FROM: 35 ILL. ADMIN. CODE 811.814	)))	AS. (Adjusted Standard)

PETITION OF COMMONWEALTH EDISON COMPANY FOR ADJUSTED STANDARD FROM 35 ILL. ADMIN. CODE 811.814

THIS FILING SUBMITTED ON RECYCLED PAPER

PETITION OF COMMONWEALTH EDISON COMPANY FOR ADJUSTED STANDARD FROM 35 ILL. ADMIN. CODE 811.814

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BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
PETITION OF COMMONWEALTH EDISON COMPANY FOR ADJUSTED STANDARD FROM: 35 ILL. ADMIN. CODE 811.814	)))	AS. (Adjusted Standard)

PETITION FOR ADJUSTED STANDARDS FROM CERTAIN REGULATIONS GOVERNING EXISTING LANDFILLS

Commonwealth Edison Company ("Edison") files this adjusted standard petition to request relief from certain of the solid waste landfill standards in 35 Ill. Admin. Code Parts 811-815 (collectively "landfill regulations") that would otherwise apply to the Joliet/Lincoln Quarry Site, IEPA Site # 1978090001 ("Lincoln Quarry" or the "Site"). Pursuant to sections 27 and 28.1 of the Illinois Environmental Protection Act ("Act") [415 ILCS §§ 5/27-5/28] and 35 Ill. Admin. Code part 106, Subpart G, Edison petitions the Board to promulgate adjusted standards for the Site that would modify the following generally applicable standards governing landfill operations: (1) the standard prescribing a leachate collection and management system; (2) the groundwater monitoring requirements for certain inorganic and organic constituents; (3) the standards for location of monitoring wells; (4) the zone of attenuation standards applicable to the Site; (5) the standard prescribing final cover for the Main Quarry; and (6) miscellaneous additional standards that factually do not apply to the mode of operation conducted at the Site.

This petition sets forth the factual and legal bases for Edison's requests. In accordance with 35 Ill. Admin. Code § 106.706, exhibits 1 through 3 provide affidavits of David P. Rubner (Commonwealth Edison Company), Robert P. Kewer and Farrukh M. Mazhar (Harza Engineering Company), and Robert G. Otto in Support of the Company's Petition for Adjusted Standards. Edison waives a hearing on this petition pursuant to 35 Ill. Admin. Code § 106.705(j).

I. INTRODUCTION.

The Lincoln Quarry Site[1] is located ¼ mile south of the Des Plaines River in unincorporated Will County, southwest of the City of Joliet, Illinois and adjacent to two of Edison's coal-fired generating stations, Joliet Stations 9 and 29. The Site consists of two former dolomite quarries comprising three units: the Main Quarry; the North Quarry; and the West Filled Area. At various times, Edison has leased and operated the Main Quarry and the West Filled Area as facilities in which it places bottom ash and slag from the Joliet Stations.

The Joliet Stations generate flyash, bottom ash, and slag as byproducts of the coal burning process. The flyash[2] from both stations is captured by electrostatic precipitators and is transported off-site for recycling or disposal. Flyash is not placed in the Main Quarry, nor does Edison seek permission for such placement.[3] This petition does not concern the handling of flyash.

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[1] As used in this petition, the phrase "Lincoln Quarry Site" or "Site" is equivalent to the Facility Boundary depicted on the Site Plan Map, Attachment GID-1, Volume I Edison's Application. See Exhibit 13.

[2] Flyash--the coal combustion byproduct that is discharged into Edison's powerplant stack--collects in electrostatic precipitators.

[3] As discussed below, flyash historically was placed in the West Filled Area.

Prior to 1975, Edison disposed of its flyash and bottom ash from the Joliet Stations in the West Filled Area. When disposal in that area ceased, the Area was leveled to grade on three sides and vegetated with Illinois prairie grass. The east wall of the West Filled Area opens on the Main Quarry.

Beginning in 1975, the bottom ash and slag from the Joliet Stations were mixed with water from the Des Plaines River and sluiced to the Main Quarry. At the urging of the Illinois Environmental Protection Agency ("IEPA" or the "Agency"), Edison received a permit to operate the Main Quarry as a landfill for coal combustion wastes in 1976. Based on recent operating experience, Edison annually has deposited between 11,000 and 34,000 tons of bottom ash and slag in the Quarry. The annual deposition rate in the future will vary depending upon the amount of electricity produced by the Joliet Stations. At current or comparable rates of deposition, the Main Quarry has the capacity to receive ash wastes from the Joliet Stations well beyond the expected useful life of those Stations.

The sluice water from the Main Quarry drains by gravity into the North Quarry settling pond. Edison pumps the water from this pond into the Des Plaines River pursuant to NPDES permit No. IL0002216. This drainage and pumping maintains the water level in the Main Quarry below the level of the surrounding natural water table.

In September 1990, the IPCB promulgated new regulations that impose more stringent design and operating requirements on existing nonhazardous waste landfills. See 35 Ill. Admin. Code Parts 810-815. Under these new regulations, operators of existing landfill facilities were required to send a notification to the Agency describing the facility, estimating the facility's anticipated date of closure, and indicating which of the new standards apply to the facility. 35 Ill. Admin. Code § 814.103. Edison originally notified the Agency that it intended to close the Quarry by September 18, 1997; however, the Quarry's significant capacity prompted Edison to amend its notification to extend closure beyond that date.

After providing notice, Edison was also required to file an application for a significant modification to its Lincoln Quarry permit by September 14, 1994, or by an earlier date specified by the Agency. 35 Ill. Admin. Code § 814.104 (b)-(c). The Agency requested Edison's application by May 15, 1994. Edison filed its application on May 13, 1994 and amended that application, based on Agency comments, on July 12, 1994.[4]

Because Edison intends to operate Lincoln Quarry as a coal combustion waste monofil beyond 1997, the Company's application was required to show that the Quarry would satisfy the standards applicable to existing landfills in 35 Ill. Admin. Code Part 814, subpart C. As Edison's application indicates, however, Lincoln Quarry cannot satisfy some of these standards. For this reason, Edison filed a petition for site-specific relief with the Board on October 17, 1994. "In the Matter of Petition of Commonwealth Edison Company to Designate the Joliet/Lincoln Quarry Site as a

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[4] A copy of the amended application is attached as Exhibit 13 to this Petition. <u>See</u> Volumes I-III, "Commonwealth Edison Company Application for Significant Permit Modification: Joliet/Lincoln Quarry Ash Landfill," prepared by Harza Environmental Services (May 1994) ("Edison Application").

Surface Impoundment or, in the Alternative, for Site-Specific Rulemaking" R 94-30 ("Rulemaking Petition"). That Rulemaking Petition requested relief from the standards listed on p.1-2 of this Adjusted Standard Petition, as well as from the groundwater quality standards contained in 35 Ill. Admin. Code § 811.320(a) and § 620.440(b).

Prior to the hearing date established on the Rulemaking Petition, Edison and IEPA agreed on an approach to address elevated concentrations of constituents in Site groundwater. IEPA has agreed, in the operating permit to be issued to the Site, to designate the Lincoln Quarry Site from the downgradient waste boundary to the corresponding Site boundary as a groundwater management zone ("GMZ"), pursuant to 35 Ill. Admin. Code § 620.250. In connection with that designation, IEPA will require Edison to implement a groundwater monitoring program within the GMZ as well as certain institutional controls.

Based on that agreement, Edison no longer requires relief from the groundwater quality standards contained in 35 Ill. Admin. Code § 811.320(a) and § 620.440(b). However, Edison still must obtain relief from the other standards that were part of the original Rulemaking Petition because those standards cannot rationally be applied to Edison's operations in the Main Quarry or because they would require Edison structurally to modify the Main Quarry in technically and economically impracticable ways for questionable environmental benefit. This Petition for Adjusted

Standard presents Edison's modified request for relief.[5]

The physical features and limitations of the existing Quarry, as well as its past and present use, account for both Edison's inability to comply fully with the new regulations and the minimal environmental impact resulting from less than full compliance. The most important facts bearing on the requested relief are as follows:

- The Main Quarry, which has been used for disposal of combustion byproducts since about 1975, was formerly a 43-acre unlined Quarry with walls and a base consisting of fractured dolomite. The floor of the Main Quarry is well below the level of the local groundwater table, prompting groundwater to flow from the surrounding areas into the Main Quarry. Even if Edison halted its sluice operations, the Main Quarry would continue to contain water. The level of that water would depend upon whether Edison continued to operate its water management system at the Site.

- The Quarry currently employs a water management system that reduces the Quarry water level below the natural water table. This system assures that the Main Quarry acts predominantly as a groundwater discharge zone, rather than as a source of groundwater recharge. It is technically difficult and economically infeasible for Edison to install any other type of water management system. It would be impracticable to line the landfill. Moreover, given that the Main Quarry is an excavation into fractured dolomite, it is technically difficult and economically infeasible to install a leachate collection system of the type commonly installed at lined landfills or landfills excavated into relatively low-permeability strata.

- The terrain around Lincoln Quarry physically limits the locations where Edison can install monitoring wells. Edison is unable to establish a network of wells at distances of 100 feet from the edge of Lincoln Quarry. Nevertheless, an alternative groundwater monitoring well network established by the Agency after consultation with Edison would be sufficient to detect any potential impact on groundwater by disposal

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[5] Edison was unable to request relief under the adjusted standard process when filing its Rulemaking Petition because of the specific requirements for adjusted groundwater standards. See 35 Ill. Admin Code § 811.320(b). Since Edison no longer requires adjustment of these groundwater standards, Edison has filed its petition under the Adjusted Standards process.

operations because the Quarry is unlined, waste disposed in the Quarry is uniform, and potential constituents in the groundwater do not attenuate before reaching the monitoring well system.

- Although the ash that Edison places in the Main Quarry contains salts, certain metals, other inorganic constituents, and trace amounts of non-toxic organic matter, it contains none of the organic constituents for which drinking water or other groundwater quality standards have been established. Thus, it is unnecessary for Edison to monitor groundwater downgradient from the Quarry for organic constituents.

- The groundwater constituents attributable to the Site occur naturally, are not carcinogens, are not bioaccumulative, and are among the least toxic of the constituents for which groundwater protection standards exist. Ash disposal activities occurring over the past 30 years apparently have increased groundwater concentrations for certain constituents above background levels at the Quarry. Because Edison operates the Quarry as a monofill, disposing only coal combustion waste, these constituent concentrations have stabilized and, if anything, will decrease over time. However, the fractured flow hydrogeology at the Site results in little or no attenuation of these constituent concentrations in groundwater. For these reasons, it is environmentally sound and practical to establish the compliance boundary, or the edge of the zone of attenuation, at the downgradient boundary for the Site. The groundwater downgradient of the Quarry discharges entirely to a segment of the Des Plaines River that complies with the applicable water quality standards and groundwater discharges to the River in the vicinity of the Main Quarry do not cause a measurable increase in the concentration of any constituent in the River.

- Before the Main Quarry reasonably and effectively could be capped, the level of the settled ash in the Quarry must exceed the maximum predicted level of the local water table plus an additional amount calculated to provide an ample margin of safety for the cap. Only at this point would the wastes in the Quarry adequately support any type of cap. At current rates of ash disposal, the Joliet Stations would close at the end of their useful lives well before the level of settled ash in the Quarry rose above the necessary level.

- Many of the standards for existing landfills were formulated to regulate units that accept dry waste for disposal in engineer cells, rather than to address the sluicing of ash waste into a former dolomite quarry. Consequently, Edison requests a finding from the Board that the standards and management practices listed on Attachment A do not apply to Lincoln Quarry.

As described below in more detail, Edison believes that these facts justify its request for relief from certain of the existing landfill standards that rationally cannot be applied to the Main Quarry. IEPA has indicated that it will address some of Edison's concerns during the landfill permit modification process; however, the Agency currently may not have the regulatory authority to modify all of the standards that must be altered to account for the unique nature of the Site. Accordingly, Edison has filed this adjusted standard petition to resolve remaining issues.

II. ADJUSTED STANDARDS FOR THE LINCOLN QUARRY SITE.

The generally applicable landfill standards that govern existing dry landfills in Illinois clearly do not apply to the wet ash handling operations conducted by Edison at the Site. Moreover, Edison's proposed adjusted standards, described below, create a preservation, monitoring, and control network that protects the environment while avoiding adverse environmental or health effects. Because the Board did not consider Edison's "wet" operations when promulgating the landfill standards, and because Edison's proposed adjustments protect the environment, the Board should grant Edison's petition for adjusted standard.

A. LEGAL REQUIREMENTS FOR PROMULGATING AN ADJUSTED STANDARD.

Sections 28.1(a) of the Illinois Environmental Protection Act authorizes the Illinois Pollution Control Board to promulgate adjusted standards to replace the generally applicable landfill requirements, if Edison makes an appropriate statutory and regulatory showing. 415 ILCS § 5/28.1; 35 Ill. Admin. Code §106.705. The five rules of general applicability described in the previous section and the standards listed on Attachment A as the subject of this petition do not specify a level of justification or other requirements necessary for Edison to receive an adjusted standard. For this reason, the Board may grant Edison's request for relief upon a showing that:

- Factors relating to Edison are substantially and significantly different from the factors relied upon by the Board in adopting the general regulation;
- The existence of those factors justifies an adjusted standard;
- The requested standard will not result in environmental or health effects substantially and significantly more adverse than the effects considered by the Board in adopting the rule of general applicability; and
- The adjusted standard is consistent with any applicable federal law.

415 ILCS § 5/28.1(c). To assist the Board in making these findings, Edison must file a petition that contains the information required by 35 Ill. Admin. Code § 106.705.

The remainder of this Petition and the Exhibits, including affidavits, provide the justification necessary for the Board to satisfy these requirements and to render its decision on Edison's petition. Part B describes the standards that Edison seeks to have adjusted and indicates that such adjustment would be consistent with federal law. Part C contains language for the Board order adjusting the relevant standards. Part D describes Edison's activities at the Site which are the subject of the proposed adjusted standards. Parts E through J describe the purpose and effect of each of the proposed rules, discuss the technical constraints and economic impediments that prevent implementation of the generally applicable standards at Lincoln Quarry, describe available treatment and control options, including the cost of each option, and assess the environmental impact of the proposed regulation at the Site. Edison submits that the information set forth in these parts provides ample justification for the Board to grant this Petition for relief.

B. DESCRIPTION OF STANDARDS TO BE ADJUSTED AND CONSISTENCY OF ADJUSTMENT WITH FEDERAL LAW.

Edison respectfully requests that the Board adjust the following standards prescribed under 35 Ill. Admin. Code Part 814 as applicable to the Lincoln Quarry Site:

- The leachate management standards of 35 Ill. Admin. Code § 814.302(b)(1).
- The groundwater monitoring requirements for inorganic and organic constituents of 35 Ill. Admin. Code § 811.319(a)(2) and (a)(3);
- The monitoring well location standards of 35 Ill. Admin. Code §§ 811.318(b)(3) and (b)(5).
- The standards in 35 Ill. Admin. Code § 811.320(c) for establishing the zone of attenuation downgradient of the Main Quarry with respect to groundwater flow;
- The final cover requirements of 35 Ill. Admin. Code § 811.314; and
- The additional requirements listed on Attachment A.

These regulations became effective on September 18, 1990 and were intended to supersede standards in 35 Ill. Admin. Code Part 807 as applied to landfills in Illinois.

The standards which Edison seeks to adjust do not implement federal or federally delegated regulatory programs as applied to the Lincoln Quarry Site. Portions of the landfill regulations were amended in October 1993 to comport with Federal Subtitle D municipal landfill standards, see 40 CFR Part 258 (Effective 10-9-93); however, because Lincoln Quarry does not accept municipal waste, the Site is not subject to these amended standards. Moreover, USEPA has restated its position that ash and slag byproducts from the combustion of coal by electric utilities are not subject to regulation under Subtitle C of RCRA or other federal standards. 58 Fed. Reg. 42,466 (August 9, 1993). Because Edison's proposed adjusted standards comport with other Federal laws, including NPDES and water quality standards, the Board may grant Edison's petition for adjusted standard consistent with Federal law.

C. **PROPOSED ADJUSTED STANDARDS.**

Edison proposes the following language to be included in a Board order adjusting the existing, generally applicable regulatory standards as requested by Edison through this Petition.

Section 1 - The standards in this order supersede the requirements of 35 Ill. Admin. Code 814.302(a), to the extent that the Joliet/Lincoln Quarry Site is exempt from those requirements under this order.

Section 2 - The following requirements shall not apply to the Joliet/Lincoln Quarry Site:

a) The final cover requirements of 35 Ill. Admin. Code 811.314;

b) The hydrogeological site investigation requirements of 35 Ill. Admin. Code 811.315, except that information shall be collected to implement a groundwater monitoring program in accordance with 35 Ill. Admin. Code 811.318 and 811.319 (as modified by this order) and establish background concentrations for the purpose of establishing water quality standards pursuant to 35 Ill. Admin. Code 811.320;

c) The well location standards of 35 Ill. Admin. Code 811.318(b)(3) and (b)(5);

d) The standards of 35 Ill. Admin. Code 811.319(a)(2) and (a)(3) concerning groundwater monitoring for inorganic and organic constituents (any cross-reference to these standards shall be interpreted as a cross-reference to this order);

e) The zone of attenuation standards of 35 Ill. Admin. Code 811.320 (c) as applied downgradient of the Main Quarry with respect to groundwater flow.

f) The leachate collection requirements of 35 Ill. Admin. Code 814.302(b)(1).

g) The standards listed on Attachment A to COMMONWEALTH EDISON COMPANY'S PETITION FOR ADJUSTED STANDARDS FROM CERTAIN REGULATIONS GOVERNING EXISTING LANDFILLS.

Section 3 - The Joliet/Lincoln Quarry Site shall be subject to the following additional standards:

a) Edison shall dispose only bottom ash and slag from the combustion of coal in the Main Quarry.

b) Edison shall operate a leachate collection and management system at the Joliet/Lincoln Quarry Site consisting of:

1) a gravity flow drainage system that:

(i) channels supernatant liquid from the Main Quarry into the North Quarry; and

(ii) assures that the water level in the Main Quarry is maintained below the natural water table level.

2) a permitted point source discharge from the North Quarry to the Des Plaines River.

The leachate collection and management system shall assure compliance with effluent limitations contained in an NPDES permit duly issued by the Illinois Environmental Protection Agency.

c) Groundwater Sampling.

1) Edison shall analyze groundwater from the monitoring well system at the Joliet/Lincoln Quarry Site, in accordance with the requirements of 35 Ill. Admin. Code

§ 811.319(a)(1), for the following constituents:

Ammonia	Fluoride	Selenium	Total Organic Carbon
Arsenic	Manganese	Sodium	Zinc
Boron	Molybdenum	Sulfate	
Cadmium	pH	Total Dissolved Solids	
Chloride	Potassium		

2) Except for the constituents monitored in accordance with 1), Edison shall sample its monitoring well system on an annual basis for all inorganic constituents for which the Board has established Class II groundwater standards under 35 Ill. Admin. Code 620.420(a).

(i) If Edison detects, and confirms through replicate sampling, a statistically significant increase above applicable groundwater standards for any constituent monitored under this paragraph, Edison shall monitor that constituent in accordance with the requirements of paragraph 1).

(ii) If, after monitoring for five years in accordance with this paragraph, Edison does not detect a statistically significant increase above applicable groundwater standards for a constituent monitored under this paragraph 2), Edison may propose as a permit modification to discontinue monitoring for that constituent.

d) Waste Sampling.

1) At least once annually, Edison shall determine the semi-volatile organic constituent content of a representative sample of waste bottom ash and slag to be disposed at the Joliet/Lincoln Quarry Site.

2) The results of such sampling shall be submitted to the Agency within 30 days after Edison receives the analytical report.

3) If Edison detects one of the semi-volatile organic constituents listed under 35 Ill. Admin. Code § 811.319(a)(3) in its ash samples, then Edison shall conduct confirmatory sampling and analysis.

4) If the sampling and analysis conducted under paragraph 3) above confirms the presence of one or more of the listed semi-volatile organic constituents, then Edison shall monitor its groundwater monitoring well system for those constituents in accordance with the sampling and analysis plan contained in Volume II of Edison's Application for Significant Permit Modification at Lincoln/Joliet Quarry Ash Landfill [IL 197809001] (May 1994).

e) Standards for Monitoring Well Locations.

1) In consultation with Edison, the Agency shall establish a monitoring well network for the Lincoln Quarry Site that achieves the monitoring objectives of Part 811. The Agency shall not impose more stringent well location standards than the requirements in 35 Ill. Admin. Code § 811.318(b).

2) If any of the wells in the monitoring network established by the Agency fails or is rendered unusable, Edison shall request permission from the Illinois Environmental Protection Agency to replace the well with another well, located as close as practicable to the non-functioning well and sampling the same aquifer.

f) Zone of Attenuation.

1) For purposes of this paragraph f), the zone of attenuation at the Joliet/Lincoln Quarry Site shall be defined as the volume bounded by a vertical plane extending from the ground surface to the bottom of the uppermost aquifer, excluding the waste, and located:

(i) 100 feet from the edge of Lincoln Quarry on the upgradient side with respect to groundwater flow; and,

(ii) at the property boundary on the downgradient side with respect to groundwater flow. If the property boundary extends beyond the annual high water mark of the Des Plaines River at any location, the zone of attenuation at that location will be reduced to satisfy the requirements of 35 Ill. Admin. Code § 811.320(c)(2).

This zone of attenuation is depicted on [Figure SAP-5, Volume II of Edison's Application for Significant Permit Modification, attached to Edison's petition for site specific relief.]

2) Groundwater quality at or beyond the zone of attenuation for the Joliet/Lincoln Quarry Site shall be maintained at each constituent's background concentration.

3) Nothing herein shall be construed to prohibit Edison from petitioning the Board for an adjustment of the groundwater quality standards applicable to the Site, in accordance with the procedures established in 35 Ill. Admin. Code § 811.320 (b).

4) Compliance Determination.

Any statistically significant increase above an applicable groundwater quality standard that is attributable to the facility and which occurs at or beyond the zone of attenuation within 100 years after closure of the last unit accepting waste within such a facility shall constitute a violation.

g) Final Cover.

1) For purposes of 2) and 3) below, "maximum adjusted seasonal water table level" means the maximum predicted water table level in the vicinity of the Joliet/Lincoln Quarry Site, determined at the time of closure, plus sufficient elevation to ensure the integrity of a cap.

2) Closure Below Water Table.

(i) If, at the time of closure, the level of settled ash in Lincoln Quarry is at or below the maximum adjusted seasonal water table level, no final cover is required for the Quarry and the Quarry shall be maintained as an impoundment.

(ii) Water levels in the Quarry shall be maintained at or below a maximum elevation of 570 feet above sea level.

(iii) A chain link fence no less than eight (8) feet in height, topped by no less than three (3) strands of barbed wire, shall be installed around the Joliet/ Lincoln Quarry Site to prevent access and shall be maintained in good condition at all times.

3) Closure Above Water Table.

(i) If, at the time of closure, the level of settled ash in Lincoln Quarry is above the maximum adjusted seasonal water table level, Edison shall install a two-stage cover system, which shall consist of a compacted clay layer that performs equivalently to a 2 foot layer of compacted soil having a hydraulic conductivity of 1×10^{-7} cm/sec, overlain by at least four inches of topsoil. The cap shall be graded at no less than 2% grade and shall drain to a collection area located on the cap. Stormwater collecting on the cap shall be pumped to the North Quarry for settling prior to discharge pursuant to the facility's NPDES permit. The cap shall be seeded to prevent erosion.

(ii) Water levels in the Main Quarry shall be maintained at no more than 570 feet above sea level through use of a gravel drainage blanket underlying the stormwater collection area. Water collecting in the drainage blanket shall drain by gravity to the North Quarry for settling prior to discharge pursuant to the facility's NPDES permit.

The remainder of this section describes these proposed standards, the efforts necessary to achieve these standards, the factual basis supporting them, and the purpose and effect of the requested relief.

D. DESCRIPTION OF EDISON'S ACTIVITIES AT THE LINCOLN QUARRY SITE.

Occupying about 100 acres, the Lincoln Quarry Site is located ¼ mile south of the Des Plaines River at the corner of Patterson and Brandon Roads in unincorporated Will County, southwest of the City of Joliet, Illinois (Sections 20 and 29, Township 35 North, Range 10 East of the 3rd Principal Meridian). Edison has leased and operated the Site as a facility for the placement of ash and slag from two coal-fired generating stations, Joliet Stations 9 and 29. Joliet Station 9 is located on land contiguous to the northwest boundary of the Site. Joliet Station 29 is located across the Des Plaines River to the north. This section describes the Lincoln Quarry Site and its surroundings, and details former and current Site operations.

1. Description of the Lincoln Quarry Site.

The Lincoln Quarry Site comprises three man-made units: the Main Quarry ("Quarry" or "Main Quarry"), used for ongoing ash disposal operations; the North Quarry, including a settling pond for ash sluice water; and the West Filled Area, used by Edison prior to 1975 for ash disposal. With the exception of the Santa Fe Railroad right-of-way, Edison either owns, or leases pursuant to a long-term renewable lease, all of the property that makes up the Site. See Exhibit 13 ["Property Plat of Station No. 9 and Vicinity," Attachment GID-7, Volume I Edison's Application]. Pursuant to the lease, Edison retains responsibility for all environmental obligations at the Quarry.

a. The Main Quarry.

The Main Quarry is directly bounded by Patterson Road to the north; Brandon Road and the abandoned, water-filled Boyd's Quarry to the east; Edison's transmission line right-of-way and farmland to the south; and the West Filled area to the West. Residential areas lie both to the northeast and southeast of the Lincoln Quarry Site.

The walls of the Main Quarry consist of the ash slope of the West Filled Area to the west and vertical dolomite rock on the other three sides. Dolomite quarrying during the 1960's and 1970's by the Lincoln Stone Company shaped the Quarry by removing all natural soils, unconsolidated materials, and the underlying dolomite stone to a depth of approximately 100 feet, at an elevation of 475 feet above sea level. The mining company probably controlled groundwater inflow into the Quarry through pumping.

When mining operations ceased, Edison leased the Quarry from the Lincoln Stone Company. Edison currently uses 43 acres of the Quarry as the active disposal site for bottom ash and slag from the Joliet Stations. Based upon contour maps, Edison estimates that the Quarry has the capacity to hold an additional 4.0 million cubic yards of bottom ash and slag. At the present rate of ash and slag generation [between 11,000 and 34,000 cubic yards annually], the Main Quarry will be available to dispose of ash waste from Edison's operations for over 300 years, well beyond the useful lives of the Joliet Stations.[6]

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[6] To date, Edison estimates that roughly 4.1 million cubic yards of ash have been deposited in the Main Quarry. The actual amount deposited could deviate significantly from this estimate, however, because this estimate presumes that the contours of the Quarry floor are level and regular. Based upon this estimate, Edison would have deposited, on average, approximately 216,000 cubic yards of ash per year into the Quarry over the last 18 years, with the larger volumes being deposited shortly after Edison began using the Quarry for disposal. The amount of ash placed in the Quarry has decreased significantly over the last several years as Edison's reliance on

(continued...)

b. The North Quarry.

Smaller than the Main Quarry, the North Quarry is bounded directly to the north by an Illinois Central Railroad Company rail spur and an access road that serves Joliet Station 9; to the east by Brandon Road; to the south by Patterson Road and the Main Quarry; and to the west by Joliet Station 9. Further north of the access road is a Santa Fe Railroad right-of-way and the Des Plaines River.

During quarrying operations, a gap in the north rock wall of the Main Quarry connected the Main Quarry to the North Quarry. This gap was used by the Lincoln Stone Company to provide access between quarrying activities in the Main Quarry and stone processing equipment in the North Quarry. The processing equipment and most processing structures were removed from the North Quarry after quarrying operations ceased.

When Edison began depositing ash in the Main Quarry, it filled the gap in the north rock wall with clean fill to form a dike that would retain sluice water from wet disposal operations. Pipes running through the dike allow sluice water to flow, under the effects of gravity, from the Main Quarry into a roughly 2 million gallon settling pond, which occupies 1.36 acres on a low area of the North Quarry floor. There are two other water-filled low areas in the northwest and southeast corners of the North Quarry, but these areas are not used in ash operations.

(...continued)
the Joliet plants to generate power has decreased.

c. The West Filled Area.

The West Filled Area consists of approximately 14 acres of the original unlined dolomite quarry that were used by Edison for disposal of flyash, bottom ash, and slag beginning in 1962. By 1975, Edison had filled this Area with approximately 2.6 million cubic yards of combustion byproducts.

Once disposal operations ceased, Edison graded the West Filled Area to ground level on the north, south, and west sides. Pursuant to a supplemental permit issued by IEPA in the early 1980's, Edison covered the surface of the West Filled Area with at least two feet of soil, graded it to drain to the Main Quarry, and vegetated the soil surface with Illinois prairie grass. The east side, adjacent to the Main Quarry, remains as a partially vegetated ash slope. After capping the West Filled Area, Edison constructed a south-to-north swale over the cap to support the sluice pipelines that are used for disposal operations into the Main Quarry.

2. Ash Disposal Operations.

Only the Main Quarry and the West Filled Area have been used as repositories for coal combustion byproducts at the Site. These units have always operated as monofills, accepting only ash waste from Edison's Joliet Stations 9 and 29. Copies of Edison's current wastestream permits are attached to Exhibit 13 [See Section 3, Volume I, Edison's Application].

a. Operations Prior to 1975.

(1) Ash Transport and Disposal.

Edison began its ash disposal operations at the Site in the 1962, after it leased the 14-acre West Filled Area from the Lincoln Stone Company for use as a waste repository. Utilizing water withdrawn from the Des Plaines River, Edison sluiced flyash, bottom ash, and slag from Joliet Stations 9 and 29 through pipelines to the West Filled Area. The ash settled to the bottom of the Area and the sluice water drained, through a pipe in the center of the ash, into a settling pond in the Main Quarry, where it combined with groundwater that flowed into the Quarry through cracks in the dolomite. The sluice water and groundwater mixture was pumped to the Des Plaines River in connection with quarrying operations to prevent groundwater flow from flooding the Main Quarry.

Concurrently with Edison's disposal activities, the Lincoln Stone Company continued its quarrying and stone processing operations in the Main and North Quarries, respectively. To separate the ash disposal operations from quarrying activities, Edison constructed an ash berm along the east edge of what is now the West Filled Area.

When quarrying operations ceased in 1975, Edison contracted with the Lincoln Stone Company to use the Main Quarry for ash disposal. Edison discontinued its disposal operations in, and appropriately covered, the West Filled area pursuant to IEPA supplemental permit No. 1982-91. That permit required Edison to level the West Filled Area on the north, south, and west sides; to cover the Area with at least two feet of soil; to grade the Area to drain; and to vegetate the Area with Illinois prairie grass. The vegetative cover effectively has controlled erosion of the topsoil over the West Filled Area. The eastern-most face of the ash berm between the Area and the Main Quarry remains uncovered.

(2) Ash Characterization.

Edison's consultant, Harza Environmental Services, determined the chemical composition of the ash in the West Filled Area by taking five samples from various depths along the boring drilled for installation of leachate well 92-10. These samples contained a fine-grained, gray to black silty ash that varied little with depth. Different depths of ash represent distinct times of deposition. Consequently, the consistent ash composition at various depths in the West Filled Area suggests that the ash composition remained relatively consistent for the entire operating life of that Area. The samples were tested for Target Compound List ("TCL") volatile organic compounds, semi-volatile organic compounds, pesticides, and polychlorinated biphenyls; Target Analyte List ("TAL") inorganics, silicon, sulfur, and molybdenum; and Toxicity Characteristic Leaching Procedure ("TCLP") metals.

These tests indicate that the ash in the West Filled Area is composed, in large part, of the following elements, listed from highest to the lowest concentrations[7]:

CONSTITUENT	MEAN CONCENTRATION (PERCENTAGE)
silicon	22.6
iron	12.8
aluminum	8.4

[7] These values reflect the percentage of principal elemental constituents in the ash expressed as a percentage of the total sample by weight.

CONSTITUENT	MEAN CONCENTRATION (PERCENTAGE)
calcium	3.8
potassium	1.5
magnesium	0.86
sulfur	0.35
sodium	0.35
barium	0.08
boron	0.07

This ash contains the following average concentrations of parameters that have been found in groundwater at the Site:

PARAMETER	CONCENTRATION
arsenic	19 mg/kg 0.017 mg/l
boron	696 mg/kg
cadmium	1.8 mg/kg 0.02 mg/l
manganese	262 mg/kg
molybdenum	20 mg/kg
potassium	14,940 mg/kg
selenium	2.6 mg/kg 0.041 mg/l
sodium	3,460 mg/kg
sulfur	3,500 mg/kg
zinc	322 mg/kg

(mg/kg determined by total metals analysis of ash).
(mg/l determined by Toxicity Characteristics Leaching Procedure)

None of the ash samples contained organic constituents with the exception of total organic carbon.

b. Operations After 1975.

From 1975 to the present, Edison has operated the Main Quarry as a surface impoundment to contain coal combustion byproducts from the Joliet Stations. After conducting hydrogeologic investigations, Edison was requested to apply for and was issued development permit No. 1976-37-DE and operating permit No. 1976-37-OP, which allowed disposal of coal combustion wastes in the Main Quarry. In 1982, IEPA issued supplemental permit No. 1982-91 to Edison. Taken together, these permits allow Edison to dispose of bottom ash and slag from Stations 9 and 29 in the Main Quarry. Edison sends flyash from both Stations directly to reuse markets or to appropriate commercial recycling and/or disposal facilities.

(1) Ash Transport and Disposal.

As one of several large fossil-fuel plants on Edison's system, Station 29 generates about 95 percent of the bottom ash and slag that is deposited in the Main Quarry. Station 9 contributes the other 5 percent. The bottom ash and slag generated at Stations 9 and 29 collect at the bottom of Edison's coal-fired boilers, where they are mixed with sluice water from the Des Plaines River. The ash-laden sluice water then flows into the Main Quarry through two parallel pipelines running from the generating stations to the Quarry's south rim. Approximately 8 million gallons per day of sluice water transport between 33 and 55 tons per day of ash and slag. This is roughly equivalent to three or four truckloads per day of dry ash and slag.

Approximately once every two to five years, Edison also transports by truck and end-dumps relatively small amounts of bottom ash and slag from station 29 over the east wall of the Quarry. This material is removed from two small surface impoundments located on the north side of the Des Plaines River. When the sluice lines from Station 29 to the Main Quarry are shut down for routine maintenance or repair, these surface impoundments serve as temporary alternate receptacles for slag and bottom ash from the Station. Water used to sluice the ash and slag to these impoundments is recycled through the water treatment facility at the Station. When the level of ash and slag in these impoundments exceeds the maximum allowable level for proper settling, Edison hires a contractor to remove and transport the ash by truck to the Main Quarry. Because Edison uses these impoundments infrequently and for brief periods, the impoundments are emptied only about once every two to five years.

On average, sluice water remains in the Main Quarry for approximately 46 days, during which time most of the bottom ash and slag settle out. As the ash and slag sink to the Quarry floor, supernatant water from the Main Quarry (including sluice water, groundwater inflow, and natural precipitation) flows by force of gravity through a series of valved discharge pipes into the North Quarry settling pond. The valved pipes run through the dike in the north wall of the Main Quarry. Approximately 8.6 million gallons per day of water flow into the North Quarry settling pond, maintaining the water level in the Main Quarry at between 549 and 555 feet above sea level.

The North Quarry acts as a polishing pond for the water from the Main Quarry. From the polishing pond, water is pumped back to the Des Plaines River pursuant to Edison's NPDES permit No. IL0002216 for outfall 005.

(2) Ash Characterization.

Because both Stations rely on the same coal source, the chemical composition of the bottom ash and slag from the Stations is comparable. Harza evaluated the chemical characteristics of the bottom ash and slag in the Main Quarry by removing a representative grab sample of ash and slag from the east side of the Quarry and testing that sample for TCLP and total metals. Based on these tests, the ash in the Main Quarry contains the following percentage concentrations of the constituents that also were found in ash from the West Filled Area:[8]

CONSTITUENT	CONCENTRATION (PERCENTAGE)
silicon	12.3
iron	1.8
aluminum	2.0
calcium	4.6
potassium	0.56
magnesium	2.3
sulfur	0.34
sodium	0.47
barium	0.10
boron	0.005

In general, these constituent concentrations are significantly lower than concentrations for the same constituents in the West Filled Area. The following table reflects the average concentrations in Main Quarry ash of parameters that have been detected in

8 These values reflect the percentage of principal elemental constituents in the ash expressed as a percentage of the total sample by weight.

groundwater at the Site:

PARAMETER	CONCENTRATION
arsenic	2.1 mg/kg <0.001 mg/l
boron	49 mg/kg
cadmium	3.0 mg/kg <0.02 mg/l
manganese	140 mg/kg
molybdenum	<12 mg/kg
potassium	5,600 mg/kg
selenium	0.5 mg/kg 0.002 mg/l
sodium	4,700 mg/kg
sulfur	3,400 mg/kg
zinc	120 mg/kg

(mg/kg determined by total metals analysis of ash)
(mg/l determined by Toxicity Characteristics Leaching Procedure)

3. <u>Site Geology</u>.

Harza Environmental Services, its subcontractors, and Edison conducted extensive geological investigations at the Lincoln Quarry Site first in 1972 and 1976 in connection with development and permitting of the Site, and again from 1992 until the present to support Edison's application for significant modification to the Site's permit. The results of these investigations have been described in Exhibit 13 [Hydrogeologic Report, Volume II of Edison's Application].

These investigations confirm that the three Quarry units are grounded in a bedrock geologic zone consisting of fractured dolomite of the Silurian and upper Ordovician geologic systems. Quarrying activities removed all natural unconsolidated materials from the Site.

4. Groundwater Conditions at Lincoln Quarry.

a. Site Hydrogeology.

Groundwater in the Joliet region generally flows within three principal aquifers: the Glacial Drift; the Silurian Dolomite; and the Cambrian-Ordovician Sandstones. At most locations in the vicinity of Joliet, the Glacial Drift aquifer flows at or just below the ground surface in unconsolidated deposits that are interbedded with or underlying glacial till. This aquifer, where present, discharges to the Des Plaines River, to other surface drainages, or to the Silurian Dolomite aquifer through fractures in the weathered upper bedrock zone. Recharge of the Glacial Drift aquifer occurs primarily through infiltration of precipitation. Because all unconsolidated surface materials were removed by quarrying activities at the Site during the 1950's, the Drift aquifer is absent and, thus, is not impacted by Site activities.

For purposes of this petition, the most relevant, as well as the uppermost, aquifer at the Site is the Silurian Dolomite Aquifer ("SD Aquifer"). Comprising parts of two dolomite bedrock units, this aquifer is bounded at its surface by the water table and at its base by the underlying dolomitic shales of the Maquoketa Group. Hydrogeologically, the SD Aquifer contains three distinct zones: an upper zone which transports groundwater; a middle, low-permeability zone which acts as an aquitard; and a lower zone which also carries groundwater. The floors of both the Main Quarry and the North Quarry rest on the bedrock that forms the SD Aquifer's upper zone.

Because the middle, low-permeability zone underlies the bedrock unit of the upper zone, the water in the Main and North Quarries is hydraulically separated across most of the Site from groundwater in the lower zone. Under parts of the North Quarry and an area north of the West Filled Area, however, the upper and lower zones may be hydraulically connected in a few locations by irregularly distributed joints, fractures, fissures, minor solution cavities, and other secondary gaps that exist in the low permeability layer. As a consequence, some groundwater travels from the upper to the lower zones in these locations. To track groundwater movement within both zones, Harza installed nested monitoring wells at several Site locations.

Below the lower zone of the SD Aquifer lie the Maquoketa shales. With a hydraulic conductivity estimated at 2.4×10^{-9} cm/sec,[9] these shales act as a hydraulic barrier, or aquitard, and form the lower geologic boundary of the Site hydrogeological system. Because of this aquitard, Edison's operations at Lincoln Quarry have no impact on groundwater flowing through the deeper, Cambrian-Ordovician aquifers ("CO Aquifers").[10] See Exhibit 13 [Hydrogeological Report, Volume II Edison Application at HR-6-7, HR-13-23].

b. Groundwater Flow.

Lincoln Quarry exerts a profound influence over the local groundwater

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[9] These shales have a conductivity that is two orders of magnitude lower than the hydraulic conductivity required by the Board for liners installed in new solid waste landfills. See 35 Ill. Admin. Code §811.306(d).

[10] These deeper aquifers consist of a thick sedimentary rock sequence interspersed with productive aquifers, including the Glenwood-St. Peter Sandstone, the Ironton-Galesville Sandstone, and the Mt. Simon Sandstone.

flow pattern. In the absence of the Quarry, all groundwater within the Silurian Dolomite Aquifer in the vicinity of the Site generally would flow directly from the southern "upgradient" areas to the north-northwest "downgradient" areas into the Des Plaines River. See Exhibit 13 [Hydrogeological Report, Volume II Edison Application at HR-19 to -20]. The natural groundwater level in the Main Quarry would range between 570 and 585 feet above sea level.

Because of Edison's water management system at the Site, much of the groundwater in the local area is diverted from its natural flow pattern into the Main Quarry and the West Filled Areas. See Exhibit 13 [Figure HR-20 "Generalized Potentiometric Elevation Surface, Upper Zone," Hydrogeological Report, Volume II Edison Application at HR-16 to HR-23]. Absent the Quarries and Edison's pumping activities, only approximately 85,000 gallons per day of groundwater would flow naturally through the site area. As part of its water management activities, however, Edison returns the ash disposal sluice water, along with other water inflow, to the Des Plaines River by pumping from the North Quarry settling pond at a rate of approximately 8.6 million gallons per day ("mgd"). This pumping reduces the water level in the North Quarry and causes water to flows by gravity from the Main Quarry into the North Quarry. The water level in the Main Quarry is maintained at between 549 and 555 feet above sea level, approximately 20 to 30 feet below the adjacent groundwater table.

The difference between the man-made water level in the Main Quarry and the natural ground water table generates a hydraulic gradient directed into the Main

Quarry. Approximately 664,400 gallons per day ("gpd") of groundwater flow from the south and east along this gradient into the Main Quarry and/or the West Filled Area. See Exhibit 13 [Hydrogeological Report, Volume II Edison Application at HR-19 and Figure HR-21 Schematic Diagram of the Site Water Budget]. This induced groundwater flow accounts for roughly 7.7 percent of the water that enters the Quarry on a daily basis (664,400 gpd out of 8,609,200 gpd). Approximately 76 percent of the groundwater that flows into the Quarry area (568,400 gpd) eventually reaches the Des Plaines River through pumping from the North Quarry settling pond pursuant to Edison's NPDES permit. The remaining 24 percent of the groundwater (175,100 gpd) discharges directly to the Des Plaines River through fractures and fissures in the Silurian Dolomite bedrock. This direct groundwater flow accounts for only 2 percent of the daily surface and ground water flow that reaches the River from the Site (175,100 gpd out of 8,737,700 gpd).

c. Groundwater Standards.

The Board has recognized that the degree of protection required for particular groundwater is in some measure a function of the resource value of that groundwater. In re Groundwater Quality Standards, R 89-14(B), IPCB slip op. at 9 (November 7, 1991). Not all groundwaters constitute the same level of resource. Id. at 9. To determine the resource value for particular groundwater, the Board considers the quality, quantity, and accessibility of that groundwater. Id.

This approach has led the Board, in its landfill standards, to adopt a two-part strategy toward protecting groundwater quality beneath and downgradient of a landfill. Groundwater within the 100 foot zone-of-attenuation around a landfill is classified as Class IV groundwater[11] that must meet the Class II groundwater standards[12] (except for concentrations of contaminants within leachate released from a permitted unit). 35 Ill. Admin. Code §§ 620.420, 620.440. Beyond the zone of attenuation, groundwater quality must be maintained at each constituent's background concentration. The background concentration is established by monitoring groundwater quality in two wells located upgradient from the landfill unit. Beyond the zone of attenuation, groundwater quality also may not exceed Illinois groundwater standards for Class I potable resource groundwater or Class II general resource groundwater. See 35 Ill. Admin. Code §§ 620.410, 620.420.

d. Groundwater Quality.

To evaluate current groundwater quality at the Site, Edison and Harza collected and analyzed six sets of groundwater samples between November 1992 and

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[11] According to the Board, Class IV groundwater is groundwater that "due to particular practices or natural conditions, [is] limited in [its] resource potential." Id. at 14. In addition to groundwater within the landfill zone of attenuation, this class includes groundwaters that are naturally saline, groundwater in mining-disturbed areas, and affected groundwaters associated with potential primary or secondary sources.

[12] Class II groundwaters includes those waters that are quality-limited, quantity-limited, or both. In re Groundwater Quality Standards, R 89-14(B), IPCB slip op. at 19 (November 7, 1991). In setting Class II standards, the Board evaluates the ability of treatment technology to improve water quality to levels suitable for potable use and may base its evaluation on MCLs as modified to reflect treatment capabilities. Some Class II standards are intended to support a groundwater use other than potability (livestock watering, irrigation, industrial use), where that use requires a more stringent standard.

November 1993.[13] See Exhibit 13 [Sampling results, Tables HR-7 through HR-10 and Attachment HR-5, Hydrogeological Report, Volume II, Edison Application]. To conduct this sampling, twelve new monitoring wells were installed, and three old wells were replaced, at representative locations both upgradient and downgradient from the Main Quarry and the West Filled Area. All wells penetrated the Silurian Dolomite Aquifer, with the exception of one well which was placed in the ash portion of the West Filled Area. Four sets of wells were screened in both the upper and lower zones of the Aquifer to determine whether contaminant migration occurs between these zones.

The groundwater analysis revealed that Lincoln Quarry has caused minimal but statistically measurable impacts[14] on downgradient groundwater quality compared to upgradient background concentrations for the following constituents:

Ammonia	Fluoride	Selenium	Total Organic Carbon
Arsenic	Manganese	Sodium	Zinc
Boron	Molybdenum	Sulfate	
Cadmium	pH	Total Dissolved Solids	
Chloride	Potassium		

See Exhibit 13 [Table HR-10, Hydrogeological Report, Volume II Edison Application]. All of these parameters occur naturally in groundwater to varying degrees.

The upgradient concentrations of these parameters uniformly satisfy applicable Illinois groundwater standards for Class I potable resource groundwater and

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[13] The dates for these sampling events are 11/92, 2/93, 5/93, 8/93, 10/93 (limited samples), and 11/93.

[14] The impacts were determined to be statistically significant by means of the procedure established under 35 Ill. Admin. Code § 811.320 (e).

Class II general resource groundwater. See 35 Ill. Admin. Code §§ 620.410, 620.420. Although elevated by comparison to background concentrations, the downgradient concentrations for most of these parameters also fall well below the relevant Class I and Class II groundwater standards. Groundwater standards do not exist for ammonia, potassium, sodium, and total organic carbon.

Groundwater exceedances, or increases over background concentrations, for boron, molybdenum, potassium, selenium, and sulfate may be attributable to past fly ash disposal operations in the West Filled Area. See Exhibit 13 [Table HR-7, Hydrogeological Report, Volume II Edison Application]. Ash samples taken from the West Filled Area contain higher concentrations of these constituents than samples taken from the Main Quarry. See section C.2.a.(2), above. Because these constituents are characteristic of leachate from flyash, which Edison deposited only in the West Filled Area, it is evident that the closed portion of the Site is primarily responsible for groundwater impacts detected for these constituents.

Groundwater sampling also indicated that groundwater constituents attenuate only minimally, if at all, in the fractured flow bedrock system underlying the Site. Harza measured constituent concentrations in leachate from monitoring wells placed at several locations downgradient of the West Filled Area. These measurements confirmed that, regardless of the distance at which the wells were located from the West Filled Area, constituent concentrations remain fairly constant as the groundwater moves through the bedrock.

e. Groundwater Use.

As discussed above, there are two aquifers below the Site [the SD Aquifer and the CO Aquifer] that, based on their ability to yield sufficient quantities of groundwater to wells, could serve as sources of groundwater for potential users. In describing groundwater use patterns at the Site, however, it is critical to distinguish between upgradient and downgradient users. Groundwater wells do exist upgradient and lateral to the Site in both the SD and the CO Aquifers. Because these wells are upgradient or lateral, however, Edison's activities do not impact the groundwater quality at these locations.

The SD Aquifer is a recognized source of residential water in northern Illinois. In the vicinity of the Site, this Aquifer has sufficient yield to be suitable for development as a domestic source, but not as a municipal, industrial, or agricultural source. A limited number of commercial users, along with several residential users, historically have drawn their water from wells in the SD Aquifer. Such wells generally are located: in upgradient residential areas east-northeast of the Site; in upgradient agricultural areas to the South; in residential/light commercial areas to the east and northeast, lateral to the direction of groundwater flow[15]; and on the north side of the Des Plaines River. None of the groundwater wells in this Aquifer is located downgradient between the Quarry boundary and the point of discharge to the Des

[15] Location information on these lateral wells is imprecise; however, the wells nearest to the Quarry are estimated to be located between 250 feet east and 1000 feet northeast from the Quarry boundary. Well locations based on available data are depicted on Figure HR-11 of Volume II of Edison's "Application for Significant Permit Modification."

Plaines River. Thus, existing wells are not impacted by Site activities.

Wells on the north side of the Des Plaines River are isolated hydrogeologically from the Site. Review of historical groundwater elevation data in the region surrounding the Des Plaines River shows that groundwater levels on both sides of the River, including levels in the Quarry, are significantly higher than River water levels. For this reason, groundwater in both the glacial drift and SD aquifers on either side of the River flows directly into the River. The River provides a hydraulic barrier, precluding flow through these aquifers from the Quarry on the south side of the River to the wells on the north side. The hydraulic impact of the River is illustrated by the potentiometric contours on figure HR-9 and by hydrogeologic cross-section on figure HR-10 of Edison's Application. See Exhibit 13 [Tables HR-9 and HR-10, Hydrogeological Report, Volume II Edison Application].

Along with the SD Aquifer, the CO Aquifers serve as potential groundwater resources in the Quarry Area. The CO Aquifers are a deeper, much more productive, and more secure groundwater resource than the SD Aquifer, in part because the aquitard over the CO Aquifers serves as a barrier to inhibit downward migration of potential contaminants. The vast majority of industrial, municipal, and commercial groundwater users upgradient or lateral to the Site draw their water primarily from the CO Aquifers. For instance, Edison, the City of Joliet, and other industrial and municipal users maintain wells in the Ironton-Galesville Sandstone Aquifer, one of the CO Aquifers. Another CO Aquifer, the Glenwood-St.Peter Sandstone Aquifer, also provides water to other commercial and industrial users.

Because all of these wells are located upgradient or lateral to the Site and beneath the aquitard, they are not impacted by Edison's activities.

By contrast, downgradient groundwater users theoretically could be impacted by Site activities. However, the risk of such impact, either now or in the future, is exceedingly small. Well boring records from the Illinois State Water Survey reveal that no wells currently exist downgradient between the edge of the North Quarry and the Des Plaines River. It also is highly unlikely that wells would be developed in this area. First, Edison either owns, or controls via long-term lease, all land between the North Quarry and the Des Plaines River with the exception of the Santa Fe railroad right-of-way. Through this control, Edison can prevent the establishment of groundwater wells in this region. Furthermore, the Illinois Environmental Protection Act and IPCB Regulations restrict the ability of groundwater users to locate new wells on land between the North Quarry and the River because all of this land falls within the minimum set-back zone for the Quarry.[16] Finally, the industrial zoning and current industrial use of this Site and the surrounding area severely limit the conversion of this land to residential or community applications that might require groundwater wells. Thus, Edison's activities do not, and in all probability will not, impact any groundwater users downgradient of the Site.

5. Surface Water Conditions at Lincoln Quarry.

As described above, natural groundwater flow patterns, along with

[16] See 415 ILCS 5/14 et seq. and 35 Ill. Admin. Code 620.210 [no new community water supply wells may be placed within 400 feet of any potential primary or potential secondary source or any potential route].

Edison's pumping activities, direct all groundwater flow in the vicinity of the Lincoln Quarry Site to the lower Des Plaines River. The groundwater enters the River on the south side of the navigation channel, along a reach that is approximately 4000 feet in length with an "active" bottom area of about 225,000 square yards. Because the lower Des Plaines River is the "only significant environmental receptor for both groundwater and surface water from the Site,"[17] the environmental impacts from Edison's Site activities must be determined by reference to water conditions in the River. See Exhibit 13 [Hydrogeological Report, Volume II Edison's Application at HR-22 to HR-23].

a. Water Quality Standards Applicable to the River.

The segment of the lower Des Plaines River which directly receives Site groundwater is located at River mile 285.15,[18] where the River comprises the flows of three highly urbanized, major tributaries: the Chicago Sanitary & Ship Canal; the Calumet-Sag Channel; and the Des Plaines River.[19] The Chicago Sanitary & Ship Canal is a man-made segment of the system that combines the redirected flow from the

[17] Because the Site operates as a surface impoundment, air migration of constituents is not a concern. See Exhibit 13 [Hydrogeological Report, Volume II Edison Application at HR-22].

[18] The confluence of the Des Plaines and Kankakee Rivers is located at River mile 273.0, as measured from the mouth of the Illinois River. Brandon Bridge is located 12.9 miles from this confluence at River mile 285.9, while the Brandon Locks are located 13.3 from this confluence at River mile 286.3. The Main Quarry is located at mile 285.9 minus 0.75 miles, or River mile 285.15.

[19] The River also receives inputs from a series of minor tributaries including the I&M Canal, the DuPage River, and Jackson Creek.

north and south branches of the Chicago River with waters diverted from Lake Michigan. Substantial discharges of treated domestic wastewater, industrial process waters, and run-off from the greater Chicago area augment this artificial flow. The Calumet-Sag Channel drains the highly industrialized areas south of Chicago, incorporating a diverse mix of process discharges and surface runoff. Finally, the Des Plaines River drains agricultural and residential areas north and west of Chicago, as well as a series of smaller urban centers. It also receives a complex mix of point source contaminants from waste treatment plants and industrial dischargers. The combination of point source discharges, including domestic sewage and industrial waste, and non-point contributions of urban and agricultural runoff have significantly degraded water and sediment quality throughout the River system.

The River adjacent to Edison's Site is used extensively as a navigation channel for barge transportation of coal, sand and gravel, petroleum products, and other bulk commodities. Flows in this segment of the River are controlled by the Brandon Lock and Dam upstream and the Dresden Lock and Dam downstream. To maintain the navigation channel, the United States Army Corps of Engineers annually dredges the River system. The frequent barge traffic and periodic dredging tend to disturb bottom sediments and maintain those sediments in suspension, further distributing those sediments, which are contaminated with trace metals and a complex variety of organic pollutants, throughout the River system.

The flow controls and extensive modifications of the River drainage, the historic and ongoing releases of contaminants to the system, and the disruption by barge traffic render the segment of the Des Plaines River adjacent to the Lincoln Quarry Site a low quality area for aquatic life. For this reason, the River is designated as a secondary contact water body, subject to the Secondary Contact and Indigenous Aquatic Life ("SCIAL") water quality standards. See 35 Ill. Admin. Code § 303.441; 35 Ill. Admin. Code Part 302 Subpart D. These standards must serve as the baseline against which the impact of Edison's activities on the Des Plaines River are measured.

b. The Quarry's Impact on River Water Quality.

As stated previously, operations at Lincoln Quarry increase groundwater concentrations of the following constituents above background levels:

Ammonia	Fluoride	Selenium	Total Organic Carbon
Arsenic	Manganese	Sodium	Zinc
Boron	Molybdenum	Sulfate	
Cadmium	pH	Total Dissolved Solids	
Chloride	Potassium		

The secondary contact standards applicable to the Des Plaines River for these constituents are listed in Exhibit 5. For purposes of comparison, Exhibit 5 also lists the inapplicable and more stringent General Use ("GU") Water Quality Standards (35 Ill. Admin. Code Subpart B) and the Public and Food Processing Water Supply Standards ("PFPWS") (35 Ill. Admin. Code Subpart C) for the same parameters.

The potentially impacted parameters at the Site are naturally occurring, ubiquitous in the system, and, except for ammonia and total organic carbon, "conservative" chemicals that do not degrade, change chemical form over time, or bioaccumulate. In general, the acute and chronic impacts of conservative constituents on local surface water quality and on resident aquatic life depend directly upon the concentrations of those constituents the a water system. The concentrations are determined by, and are inversely proportional to, the degree of dilution that is available in the River. Thus, the impact of Edison's Site activities on the lower Des Plaines River for the conservative potentially impacted parameters will depend largely upon the degree of dilution that occurs as the groundwater discharges to the River.

Like the "conservative" potentially impacted parameters, ammonia and total organic carbon ("TOC") occur naturally in the River at low levcls[20] and are not bioaccumulative.[21] These constituents are not considered "conservative," however, because they form chemical "complexes" that degrade over time due to physical conditions in the River, bacterial action, and other factors. As the time or distance downstream from a particular discharge increases, the degradation of the ammonia or TOC from that discharge reduces the expected concentrations of these constituents in the River. The dilution available in the River also reduces the available concentrations. As these concentrations decrease, the impacts on aquatic life that might be associated with these constituents also would decline. Consequently, the impacts on the lower Des Plaines River from groundwater discharges of ammonia and TOC will be reduced both by degradation of the constituent "complexes" and by the available dilution, decreasing the potential for adverse impacts even below the undetectable impacts

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[20] The natural concentrations of ammonia and TOC in the River are enhanced upstream from the Site due to the discharge of domestic and industrial wastewaters.

[21] Ammonia does not bioaccumulate. Furthermore, there is no reason to believe that the compounds comprising the total organic carbon in the groundwater are bioaccumulative because Harza did not detect any priority organic pollutants in groundwater at the Site.

projected for conservative chemicals which are influenced only by dilution.

Calculation of the fully mixed concentrations for the potentially impacted parameters that would be added to the lower Des Plaines River by groundwater discharge demonstrates clearly that Edison's operations at Lincoln Quarry have no impact on River water quality. These fully mixed concentrations can be calculated by multiplying the concentration of the constituent in the groundwater by the volume of groundwater flow and then dividing that total by the sum of the groundwater flow plus the River flow[22]:

$$\text{Contribution to the River} = \frac{[\text{groundwater concentration}] * [\text{groundwater flow}]}{[\text{River flow} + \text{groundwater flow}]}$$

This computation was complicated at the Site by the fact that groundwater flows to the River from two distinct locations, the Main Quarry ["MQ"] and the West Filled Area ["WFA"]. To address these disparate flows, the above computation was modified, as indicated below, to account for the contributions from each location[23]:

$$\frac{[\text{MQ concentration}]*[\text{MQ groundwater flow}] + [\text{WFA concentration}]*[\text{WFA groundwater flow}]}{[\text{MQ groundwater flow}] + [\text{WFA groundwater flow}] + [\text{River Flow}]}$$

MQ concentration = concentration from Exhibit 7.
WFA concentration = concentration from Exhibit 8.

The results of these calculations are presented on Exhibits 7-9.

In performing all of these calculations, the following assumptions were

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[22] An average incremental groundwater concentration from each area also can be calculated by subtracting the statistical background concentration of the constituent of concern from the average groundwater concentration. See Exhibits 7 and 8.

[23] An incremental contribution to River concentrations also can be calculated based on the incremental concentrations from each area and the formula set forth above. See Exhibit 9.

used. The River flow has been conservatively assumed to be 1800 CFS (the approximate 7Q10 flow). The background concentration in the River of each potentially impacted parameter is assumed to be zero.[24] Groundwater flows from the Quarry are estimated at 101,400 gpd from the Main Quarry and 73,700 gpd from the West Filled Area. Groundwater flows were based on six rounds of groundwater data, taken on approximately a quarterly basis, from a network of wells installed to capture groundwater from three general locations: (1) upgradient of the Quarry (five wells); (2) downgradient of active Quarry Operations (five wells); and (3) downgradient of the West-Filled Area (four wells). These wells were observed in 11/92; 2/93; 5/93; 8/93; 10/93; and 11/93.

Exhibits 7-9 provide the results of the above computations. Exhibit 7 presents average concentrations for the potentially impacted parameters in groundwater flowing from the Main Quarry. Exhibit 8 presents the same concentrations for groundwater flowing from the West Filled Area. Exhibit 9 estimates the total constituent contributions to the River attributable to groundwater discharge from the Site and compares these total contributions to the annual average upstream River

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[24] This assumption was used to facilitate comparisons between concentrations of different constituents and to reflect the fact that the groundwater discharge results in minimal but positive mass loadings to the River for all potentially impacted parameters. When actual upstream River concentrations are taken into account, the groundwater discharge actually reduces, to a small degree, instream River concentrations through dilution for most potentially impacted parameters, because the constituent concentrations in the groundwater fall far below the ambient River concentrations.

concentrations and the standard deviations for each of the potentially impacted parameters.[25]

As can be seen on Exhibit 9, the incremental effects on River concentrations resulting from the discharge of the potentially impacted parameters from the Site fall well within the natural variation for River concentrations of these parameters, as approximated by the standard deviation. Further, the total incremental increases in River concentrations attributable to groundwater from the Quarry fall well below the method detection limits for the analytical methods applicable to the potentially impacted parameters (See Exhibit 9). Thus, these contributions to River concentrations could not even be detected through use of standard analytical techniques. Finally, the conclusion that Quarry operations do not adversely impact water quality is fully supported by available surface water quality data. See Exhibit 10.

In sum, the groundwater calculations and available water quality data confirm that Edison's ash disposal activities have little, if any, measurable impact on surface water quality near the Lincoln Quarry Site. Moreover, additional control of groundwater discharges from the Site to the River, for example by installation of a leachate collection system to eliminate the minimal uncontrolled flow of "leachate"

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[25] The standard deviation provides one method for expressing the expected normal statistical variation around the average for the upstream River concentrations of the potentially impacted parameters, absent effects from Edison's operations. For example, in the case of boron, the mean upstream River concentration is 0.17 mg/L with a standard deviation of 0.0083. Based on statistical analysis and natural variability, 95 percent of the time the upstream boron concentration in the River will be 0.17 mg/L $\pm$ [2 x 0.0083], or between 0.1534 mg/L and 0.1866 mg/L.

from the Site directly to the River, would have no measurable or discernable impact on River water quality or, indeed, on any environmental receptors. Edison's current method of collecting and managing "leachate" from the Main Quarry limits potential environmental impacts. Exhibit 11 discusses the constituent-by-constituent impacts of groundwater discharges from Lincoln Quarry to the Des Plaines River.

6. Surrounding plant and animal habitat.

Virtually all of the plant and animal habitats at Lincoln Quarry have been disturbed by continuous industrial activity, which began in the first half of this century, well before the disposal activities that are the subject of this petition. Mining operations in the dolomite quarries on the Site removed all natural top soils and unconsolidated deposits, drastically altering local topography. Remaining portions of the Site are wooded, containing boxelder, eastern cottonwood, and white ash. Edison also vegetated the cover over the West Filled Area, and one-third of the slope between the West Filled Area and the Main Quarry, with native prairie grasses.

Because the Main Quarry operates as a surface impoundment, only local scrub brush survives on two-thirds of the ash slope between the Main Quarry and the West Filled Area. After quarrying ceased, portions of the North Quarry became overgrown with a variety of brush, scrub trees, and grasses. The habitat surrounding ponded water at low points in the North Quarry is dominated by American elm, willows, and cattails. If Edison discontinued pumping operations from the North Quarry, the low ponded area and its attendant vegetation would be inundated. Both Quarries support species of fish and small animal life, including beavers.

7. Land Use At and Around the Lincoln Quarry Site.

Edison's Joliet generating Stations 9 and 29 are located on opposite banks of the Des Plaines River in a heavily industrialized section of unincorporated Will County near Joliet, Illinois. See Exhibit 4. Station 9 dates back to 1929. Station 29 was constructed in 1962 and first generated electric power in 1965. The Stations cumulatively employ approximately 500 people, with the majority working at Station 29. Edison pumps potable water for its employees from a well drilled into the lower CO Aquifers. See discussion at pp. 42-44. With the exception of this deep well, there is no groundwater usage within or downgradient of the Site.

The land owned by Edison in the vicinity of the generating Stations is zoned I-3 for intensive industry. Adjacent to Station 9, the West Filled Area and the Main Quarry are zoned A-1* for special agricultural uses. The North Quarry is zoned I-3* for special intensive industrial use.

On adjacent property to the west and upgradient of Station 9, Olin Chemical Corporation owns a large chemical manufacturing facility that is zoned I-3 for intensive industrial use. As of October 1, 1990, 230 employees at Olin engaged in the production of sodium fluoride (used to fluoridate municipal water supplies) and industrial sodium phosphates. See Olin Corp. v. Illinois EPA, PCB No. 89-72 (Variance), 1991 Ill. Env. LEXIS 106 at *3-*4 (Feb. 7, 1991). In connection with these activities, Olin operated a large, on-site gypsum slurry pond from which water was discharged to the Des Plaines River pursuant to an NPDES permit. Id. A portion of the facility was shut down in mid-1991 and the current operating status of this facility is unknown. See Olin Corp. v. Illinois EPA, PCB 89-72 (variance) 1991 Ill. Env. LEXIS 360 (May 9, 1991). Southwest of the Olin Property, a subsidiary of WMX Technologies, Inc. operates ESL Landfill, a sanitary waste landfill, on property zoned for special agricultural use (A-1*). Adjacent to this municipal waste landfill is a closed hazardous waste landfill.

The areas immediately south of the Site have been zoned I-2 for general industrial use. Small businesses operate along Brandon Road in this region. Areas further south have been zoned A-1 for general agricultural use. All of this property is located upgradient of, and is unaffected by, Site operations.

Predominantly single family residences (zoned R-3 and R-5) and very small commercial shopping areas (zoned C-1 and C-1*) are located to the east and northeast of the Site. Boyd's Quarry, an abandoned dolomite quarry unrelated to Edison's Site, also lies east of the Main Quarry. According to 1990 United States Census Bureau data and United States Geological Survey maps, about half of the population in these residential areas obtains water from municipal or private water systems. The remaining residents obtain water from wells drilled in the SD Aquifer. These wells are upgradient of or lateral to the Site and, therefore, are unaffected by Edison's operations. Significant population centers associated with the City of Joliet are located north of the Des Plaines River; however, the River separates these regions hydraulically from the Lincoln Quarry Site.

8. Factual Summary.

In this Petition, Edison has requested that the Board promulgate adjusted standards that take into account the unique circumstances at the Lincoln Quarry Site.

The most relevant of these circumstances, discussed above, include:

- For approximately 30 years, Edison has operated the Lincoln Quarry Site as a disposal area for ash from the Joliet Stations.

- The ash currently disposed in the Main Quarry contains significantly lower concentrations of the potentially impacted parameters than the ash that was deposited in the West Filled Area until about 20 years ago.

- Edison's operations have resulted in only minimal environmental impact on groundwater and no discernable impact on other potential receptors, including the Des Plaines River.

- To the extent that groundwater degradation can be attributed to Lincoln Quarry, that degradation apparently arose primarily because flyash was placed in the closed West Filled Area. Current disposal activities have not exacerbated this degradation. Moreover, monitoring data indicate that existing groundwater quality conditions are stable. Because concentrations of constituents in the groundwater can be expected slowly to decrease over time, the change in standards will have no further adverse effect on the groundwater. Similarly, requiring Edison to halt current disposal activities or to take added precautions in connection with current disposal practices would not be effective to prevent continuing exceedances of current groundwater standards.

Even without implementation of the stringent requirements in 35 Ill. Admin. Code Parts 810-815 at the Site, the data presented above clearly demonstrate that Lincoln Quarry has a negligible impact on the environment. For this reason, adjusting the landfill standards as requested by Edison "will not result in environmental or health effects substantially and significantly more adverse" than would be achieved if the generally applicable standards were implemented. The remainder of this petition discusses the specific standards from which Edison seeks relief.

E. LEACHATE COLLECTION SYSTEM

Section 814.302(b)(1) of the regulations applicable to existing landfill units requires use of a "system which will effectively drain and collect leachate and transport it to a leachate management system." 35 Ill. Admin. Code § 814.302(b)(1). The regulations define leachate as any "liquid that has been or is in direct contact with a solid waste." 35 Ill. Admin. Code § 810.103. At Lincoln Quarry, such liquid includes 7,862,200 gallons per day of sluice water that carries the ash to the Main Quarry, 605,700 gallons per day of groundwater that flows into the Main Quarry under the influence of the inward hydraulic gradient, and 11,100 gallons per day of net precipitation [minus evaporation] that reaches the Main Quarry. The landfill regulations would require Edison to maintain a system that effectively drains, collects, and manages this water. Edison, in turn, asks the Board to find that the current gravity-based water management system operated by Edison at the Site satisfies these regulatory standards.

1. Conditions at Lincoln Quarry Differ from Conditions Considered by the Board when Adopting the Leachate Collection Standards.

The Board's leachate drainage, collection, and management standards in 35 Ill. Admin. Code §§ 814.302(b) do not describe a specific system that must be used to collect and manage leachate at an existing landfill. In promulgating this standard, however, the Board clearly did not contemplate managing leachate at Lincoln Quarry using typical management techniques.

Traditional leachate collection and management systems handle much smaller volumes of water than would be present at Lincoln Quarry. On average, Edison handles 8.5 million gallons per day of "leachate" through its gravity flow drainage system. Under daily operating conditions without a cover, a leachate collection system at a more representative landfill would be designed to handle about 1000 gallons of leachate per acre per day. At the Lincoln Quarry Site, this would amount to a leachate collection system designed to handle 44,000 gallons of leachate daily, or 0.52 percent of the "leachate" actually generated by the Site. Moreover, the depth of "leachate" above the Quarry floor is consistently between 25 and 45 feet, even during operation of the gravity flow system. By comparison, the Board's leachate collection standards for new landfills require design of a system that maintains a maximum leachate head of one foot above the landfill liner during the wettest months. See 35 Ill. Admin. Code § 811.307; See In re Development, Operating and Reporting Requirements for Non-Hazardous Waste Landfills, IPCB No. R88-7 slip op. at 2 (February 25, 1988) incorporating Recommendations for a Non-Hazardous Waste Disposal Program In Illinois, Scientific and Technical Section, IPCB No. 84-17, Docket D at 40-41 (March 7, 1988) (hereinafter "Landfill Recommendations") (discussing inward gradient landfills). Finally, although the Board considered inward-gradient landfills to offer "a practical solution to areas that have high water tables," the Board did not address collecting leachate at such landfills where the groundwater inflow averages 605,700 gallons per day. See Landfill Recommendations at 41. The substantial daily water inflow at Lincoln Quarry justifies use of a leachate collection and management system tailored to address specific site conditions.

2. Installation of an Alternative Leachate Collection and Management System at the Site Would Present Significant Technical Challenges and Would be Very Costly.

Installation of a leachate collection and management system at the Site to replace the current gravity flow system would be prohibitively expensive and present significant technological challenges. To minimize the amount of leachate that escapes from a site, traditional leachate collection and management systems first restrict the amount of water that reaches the waste and then collect and manage the water that circumvents the control system. As discussed below, these leachate control objectives are incompatible with Edison's current operating practices and present difficult technical issues.

As indicated, Edison sluices its ash waste into the Main Quarry and operates the Quarry as a surface impoundment.[26] This mode of operation obviously prevents Edison from limiting the volume of water that reaches the waste. If Edison cannot limit this water volume, however, traditional leachate collection and management systems become infeasible at the Site because the amount of "leachate" generated would greatly exceed the amount typically controlled by such systems. A typical landfill uses one of two methods to collect leachate: (i) an underdrainage system located beneath the waste and above a low permeability bottom liner in newer

[26] Edison's operating practices are among the most widely and commonly used disposal methods for bottom ash and slag. United States Environmental Protection Agency, Report to Congress: Wastes from the Combustion of Coal by Electric Utility Power Plants, EPA/530-SW-88-002, § 4.2.1.1 at p. 4-11 (February 1988) ("Report to Congress"). The majority of ash disposal sites operated by utilities in Illinois are operated as surface impoundments.

landfills; or (ii) leachate recovery wells that are drilled into the waste from the top of existing or older landfills. For different reasons, neither of these typical leachate collection systems would be technically practicable at Lincoln Quarry.

An underdrainage system could be installed in one of two places at Lincoln Quarry: above the existing waste to collect and manage leachate for future waste placement; or below the existing waste. Installing such a system above the existing waste would not effectively address the leachate escaping from waste already placed in the Main Quarry. Groundwater would continue to enter the Quarry, move through the waste, and migrate downgradient, as is presently occurring. Thus, such an underdrainage system would have no impact on leachate generated at the Site.

Rather than placing the underdrainage system on the existing waste, Edison theoretically could remove the existing waste, line the fractured dolomitic rock base and walls of the Main Quarry, and install a low-permeability layer and a leachate collection system. Construction of such a multi-faceted system would be technically impracticable and prohibitively expensive because of the nature and size of the Site. Moreover, such a system would require Edison to switch from wet to dry ash disposal methods in the Main Quarry, raising significant concerns about particulate emissions from ash handling and deposition into the Quarry.

Constructing a leachate management system under the existing waste probably would require Edison to perform at least the following activities. First, for the duration of construction, all sluice water carrying ash from Stations 9 and 29 would be redirected from the Main Quarry to alternative settling basins. Because the capacity of the current settling basins at Station 29 probably would be insufficient to accommodate the flow of sluice water from both Stations, Edison would need to design and construct new settling ponds at an estimated cost of $1.2 million. It is unclear where Edison could locate such ponds since insufficient open space exists at the Site for construction of an adequate settling basin system. Moreover, the large volume of bottom ash and slag handled by the Site on a daily basis would require Edison frequently to excavate the settling ponds and to truck the dry ash to an alternate disposal location.

Next, Edison would need to dewater the Main Quarry and to maintain the dewatering system throughout construction of the underdrainage system. To prepare the Site for dewatering, Edison would need to install a physical barrier, such as a grout curtain, along the upgradient sides of the Quarry. The physical barrier would reduce the rate of groundwater seepage into, and thus the volume of water to be pumped out of, the Quarry, both in the short term and over the life of the facility. The construction of an upgradient grout curtain would cost approximately $2.0 million.

After constructing the grout curtain, Edison would have to dewater the Quarry to remove both the existing 244,371,600 gallons of water and the daily groundwater inflow of 600,000 gallons per day.[27] This water could be removed in two phases. Initially, Edison could use the current gravity drainage system to direct water

[27] These figures presume that Edison has redirected the sluice water from the Main Quarry to other settling ponds. In addition, the daily groundwater inflow probably would be reduced somewhat by installation of the grout curtain. The effectiveness of the grout curtain will determine, in part, the rate at which the Quarry can be dewatered.

to the North Quarry, followed by pumping from the North Quarry to the Des Plaines River. When the water level in the Main Quarry falls below the level of the gravity drain, Edison could install water pumps to complete the dewatering and maintain the Quarry in a dry state. To dewater the Quarry in 30 days would require pumping at a rate of approximately 8,750,000 gallons per day or 5,700 gallons per minute. At a more modest pumping rate of 500 gallons per minute [720,000 gallons per day], which is just sufficient to exceed the rate of groundwater inflow, it would take over 2000 days to dewater the Quarry.

Because these dewatering activities would disturb previously settled ash, it is probable that the concentration of suspended solids in the water pumped to the North Quarry would increase significantly over current concentrations. As a result, Edison would be required periodically to dredge the settling basin in the North Quarry to remove the solids and to promote additional settling. The concentration of suspended solids discharged to the Des Plaines River also potentially could increase. This environmental consequence of dewatering activities undertaken to install an underdrainage system must be weighed against the environmental benefits, if any, to be gained from such a system.

After dewatering the Main Quarry sufficiently to reveal some of the settled ash, Edison could begin to remove and temporarily relocate the wet ash (6 million tons from the Main Quarry and 4 million tons from the West Filled Area) to expose the underlying bedrock. Dewatering would continue during removal. Ash could be removed through dredging, sluicing, excavation, or some combination of these methods, and then temporarily relocated, at a cost of approximately $25 million. See Exhibit 12 option 7B (excavation and disposal).

The large volume of ash that would be removed from the Main Quarry would have to be stored and managed temporarily during construction of the Site's underdrainage system. Such storage and management would raise significant difficulties. First, it is unclear whether and where Edison could locate or build a storage and management facility in a short time frame with sufficient capacity to hold the ash. Second, it would be very expensive to dispose of this ash. If the waste were permanently disposed off-site at a commercial facility, the additional cost would exceed $150 million. See Exhibit 12 option 7B (excavation and disposal). If, instead, Edison constructed a new on-site facility, the costs would be at least $19.5 million (52 acre cell, including land acquisition, design, permitting, construction, and QA/QC). See Exhibit 12 (cost estimates-new disposal facility). Finally, the environmental impacts attributable to storage and management of the ash would be significant, including impacts to air [dust management], water, and land [traffic flow] from dredging and transport of the ash; and impacts from siting and construction of a new disposal facility or from increased disposal volume at an existing facility. Again, these impacts must be weighed against the minimal environmental benefits to be achieved by constructing an underdrainage system.

Once all of the ash is removed, Edison would install a three-phase leachate control system on the sides and bottom of the Quarry bedrock. This system would consist of a groundwater gradient control layer (underdrainage layer) to collect groundwater inflow and to protect the liner from excessive uplift pressures; a low-permeability liner system; and a leachate collection system. Installation of this three-phase system would present significant technical obstacles. Because the rock side walls of the Quarry are tall, nearly vertical, and irregular, it would be very difficult to install any type of liner without first removing large amounts of stone. Moreover, the only feasible means of lining the Quarry walls would be to install a clay layer, which could be built with no steeper than a 2:1 slope to address both safety and construction requirements. Even if Edison could overcome these technical difficulties, installation of a liner and underdrainage system would be cost-prohibitive.

After the underdrainage and leachate collection systems were installed, Edison could redeposit the ash that it removed from the Quarry. For new ash disposal, however, Edison would be required to switch from wet to dry ash handling practices to comply with the new landfill regulations and to maintain the integrity of the underdrainage and leachate collection systems. This switch would require Edison permanently to divert its sluice water containing ash from the Main Quarry into the ash settling ponds that it constructed to facilitate installation of the leachate management system. Edison would be required frequently to excavate these ponds because of the large volume of ash and slag that it handles on a daily basis. The additional environmental consequences attributable to dry ash handling practices are unclear, but might include increased worker exposure to ash waste, increased truck traffic between the settling basin and the Main Quarry, and dust generated by dumping the dry ash into the dry Quarry. All such environmental consequences must be weighed against any projected benefit from installing a leachate collection system.

As an alternative to installing a leachate collection system, some existing or old landfills drill leachate recovery wells through the waste at or near the downgradient boundary of a disposal cell. Such wells pump leachate from the waste to a leachate management system. Regardless of whether Edison uses wet or dry disposal methods at the Site, the use of leachate collection wells is not a technically viable method for addressing Site leachate.

The purpose of a leachate recovery well system is to remove liquid generated at a landfill. Under wet disposal conditions, however, the ash placed in the Main Quarry remains continuously saturated with 8.6 million gallons per day of sluice water, precipitation, and groundwater. It would be impossible for Edison to remove this amount of leachate on a daily basis through collection wells. Moreover, to the extent that the wells could recover some leachate, pumping the wells would actually increase the amount of liquid that flows directly through the ash waste. By pumping, Edison would create a localized inward hydraulic gradient at the well location, drawing additional sluice water, precipitation, and groundwater through the ash to the well. This water would contain very high concentrations of fine suspended sediment, which either would clog well screens, making the wells non-productive, or would be discharged to the North Quarry settling basin. By contrast, absent this pumping activity, much of this additional water would flow from the Main Quarry via gravity to the North Quarry, after the fine sediment had already settled. Thus, the primary effects, if any, of pumping leachate collection wells under wet operating conditions would be to increase the amount of leachate generated in the Main Quarry and to transfer significant quantities of suspended sediment from the Main Quarry to the North Quarry.

Converting the Site from wet to dry operations would not enhance the effectiveness of the leachate recovery wells. Because the Main Quarry is very large and acts as a groundwater sink for the surrounding area, a tremendous number of wells would be required to divert the large volume of water that flows into the Quarry on a daily basis. The low permeability and fine-grained nature of the ash waste would further increase the required number of wells. By limiting the distance through which a well can draw water and by routinely clogging well screens, fine-grained material severely restricts a well's zone of influence and decreases the well's pumping efficiency. To achieve sufficient "draw-down" in such wells to ensure that all of the Quarry leachate had been collected, Edison would need to maintain the Quarry water level below the level of the Des Plaines River, and approximately 70 feet below the level of the water table in the surrounding area. It is improbable that Edison could pump sufficient quantities of water from leachate recovery wells to achieve this objective and to reduce significantly the amount of leachate generated at the Site.

Finally, regardless of whether the Site conducts wet or dry operations, Edison would face significant obstacles to installation of the collection wells. Either Edison would be required to dewater the ash, in the manner described above, or would need to use a barge to access the north wall of the Quarry for well installation. Because this leachate collection method is not technically viable, costs have not been developed for this scenario.

Given the impracticability of these traditional leachate collection techniques, Edison also evaluated more advanced leachate management technologies. Like the traditional tools, however, these less common methodologies are technologically impracticable and cost prohibitive at the Lincoln Quarry Site. The major techniques that were evaluated are discussed below.

At many sites, contaminated seepage from an identified source may be collected through use of a leachate collection trench. Such a trench typically is constructed by excavating downgradient of a contamination source and then backfilling the excavation with permeable granular soil, which acts as a sump to collect contaminated seepage. Because the area downgradient of the Main Quarry consists of solid rock, construction of a collection trench, by excavating rock in this area through drilling and blasting, would be prohibitively expensive. Also, the space between the Main Quarry and the North Quarry probably is insufficient to foster safe construction of such a trench. A trench conceivably could be constructed directly in the ash along the north wall of the Quarry; however, the nature of the ash waste material and wet operation of the Quarry render use of this technology impracticable at this Site.

Before a trench could be constructed in the ash, Edison would need to dewater the Quarry, as described above, to allow construction equipment access to the waste. Then, Edison could attempt to excavate a trench through approximately 65 feet of ash to the Quarry floor. Construction of such a trench would be technically difficult, however, because the ash material in the Quarry is non-cohesive, resulting in unstable side walls for a trench of this depth. Use of typical trench stabilizing materials, like slurries, would be inappropriate at this Site in light of the purposes for which Edison would be constructing this trench. A slurry consists of fine particles blended with water that prevents the collapse of a trench's side walls both by maintaining an outward pressure and by clogging the porous spaces between the ash particles comprising the walls. This approach is appropriate for a physical barrier, such as a slurry wall, that is intended to impede water flow. However, use of slurry material to stabilize the side walls of a leachate collection trench unacceptably reduces the permeability of the ash adjacent to, and limits the flow rate of "leachate" migrating into, the trench.[28] In short, use of a downgradient leachate collection trench is technically impracticable at this Site.

As its final leachate collection alternative, Edison rejected construction of a downgradient drainage gallery tunnel, with drain holes to accumulate leachate seepage from fractures and joints in rock walls. Such a drainage gallery would consist of a long, sloped tunnel drilled in the rock wall between the Main and North Quarries and below the water table at an elevation of about 520 feet above sea level. Radial holes drilled from within the tunnel into the rock, at determined locations and angles, would increase the tunnel's zone of influence. As water within rock fractures reached

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[28] In recent years, some companies have used biodegradable slurries to install drainage trenches. This technique utilizes a material which keeps the trench excavation open temporarily for placement of the drainage system and then biodegrades to allow collection of water in the trench. Although this technology has been used to construct trenches of up to 40 feet deep, it is still evolving. Most significantly, the feasibility of this technique at depths approaching the 65 feet required at the Site is unproven.

the radial holes, it would drain through these holes into a concrete-lined drainage ditch in the tunnel, which would convey it to a water management system. To effectively collect 80 to 90 percent of the minimal "leachate" volume that bypasses Edison's current water management system, this gallery would need to be approximately 2500 feet [½ mile] long and 65 square feet in cross-sectional area. Five hundred drain holes of approximately 35 feet in length would be placed at intervals of approximately 10 feet, radiating both upwards and downwards from the gallery.

Significant additional engineering evaluation would be necessary to determine definitively whether installation of a downgradient drainage gallery would be technically feasible at this Site. To Edison's knowledge, no tunnel of this type has been installed to collect leachate from a landfill. Depending upon where the tunnel would be located in the rock wall between the Main and North Quarries, and upon how the radial arms of the tunnel would be drilled, the tunnel conceivably could fail to intersect the most significant joints and fractures in the rock wall. If this occurred, much of the leachate flowing through the Main Quarry would entirely bypass the tunnel. Moreover, it is unclear whether the quality and width of the rock wall between the Main and North Quarries would support construction of a stable tunnel. Finally, construction of the drainage gallery might reduce the stability, or otherwise interfere with current uses, of a country road that runs over the proposed tunnel location.

Even if installation of a drainage gallery were technically feasible, construction and operation of this system under ideal conditions would be cost prohibitive. Installation of the drainage gallery and drain holes alone would cost approximately $4,231,000. See Exhibit 12 [cost estimate-drainage gallery]. If additional efforts were required to stabilize the tunnel walls, the construction costs could increase significantly. Operation of the system [not including groundwater treatment] would cost approximately $20,000 per year. Assuming at least a 50 year operating life [20 year life of the facility plus 30 year post-closure period], this would amount to a present value of about $4.7 million to collect less than 4 percent of the water that reaches the Main Quarry on a daily basis. It is economically unreasonable to expend this money to achieve the imperceptible environmental benefits discussed above.

3. Description and Costs of Operating Edison's Proposed Leachate Management System

Under its proposed adjusted standard, to manage the approximately 8.6 million gallons of water that flow through the Main Quarry on a daily basis, Edison would continue to operate its gravity-flow drainage system. This system consists of: (1) drainage pipes that draw water by gravity from the Main Quarry into the North Quarry; and (2) a pumping station that discharges the water from the North Quarry into the Des Plaines River pursuant to an NPDES permit. Edison would expend approximately $150,000 per year at present value to operate this system, including capital costs to replace slag lines and pumps and operating costs for the pumps.

The inward hydraulic gradient created in the Main Quarry by Edison's water management system limits the outflow of leachate from the Main Quarry into groundwater to less than 236 gallons per minute [339,150 gallons per day], or approximately 4 percent of the water reaching the Main Quarry on a daily basis. See

Exhibit 13 [Hydrogeological Report, Volume II Edison Application at p. HR-19 and Figure HR-21 Schematic Diagram of the Site Water Budget]. Of this volume, approximately 70 percent [237,750 gallons] travels about 100 feet before reaching the North Quarry settling pond, from which it is pumped into the Des Plaines River. Thus, Edison's gravity flow drainage system captures all but 101,400 gallons per day (including precipitation that falls on the North Quarry, recharge from the North Quarry, and groundwater flow from the Main Quarry) or 1.2 percent of the water volume reaching the Site. Any additional leachate collection and management system that Edison might install under the generally applicable regulations would address this minimal 1.2 percent incremental water volume that bypasses the present collection system.

4. Edison's Proposed Leachate Management System Effectively Minimizes the Environmental Impact of Leachate Generated at the Site.

Installation of an alternative leachate collection and management system to capture the incremental water volume that bypasses Edison's gravity flow drainage system would result in little, if any, discernable environmental benefit. The purpose of an alternative leachate collection system would be to collect the minimal "leachate" that otherwise would flow directly to the Des Plaines River and channel that leachate to Edison's current leachate management system. That system would then discharge the "leachate" to the Des Plaines River, along with Edison's sluice water, pursuant to an NPDES permit. By installing an alternative leachate collection system, then, Edison merely would have relocated the discharge point for the "leachate" from the bedrock adjacent to the River to its NPDES discharge. From an environmental perspective, this might reduce potential exposure of receptors located between the Main Quarry and the Des Plaines River to groundwater containing "leachate." Because there are no wells or other known environmental receptors in this region, however, the only practical effect of installing an alternative leachate collection system would be to move the discharge point for the minimal groundwater volume.

5. Summary.

Because the incremental costs and technical hurdles associated with installing an alternative leachate collection system at Lincoln Quarry would be high, and because the environmental benefits, if any, to be gained from such a system would be minuscule, Edison has requested an adjusted standard which allows Edison to operate its current water management system as the leachate collection system for the Site.

F. CONSTITUENT MONITORING

Section 811.319 of the generally applicable landfill standards requires Edison to monitor Site groundwater:

- Quarterly for all constituents that appear in or are expected to appear in

Edison's leachate and for which the Board has established a water quality or groundwater standard;

- Quarterly for all constituents that appear in or are expected to appear in Edison's leachate and which may cause or contribute to groundwater contamination; and

- Once every two years for the 51 organic constituents monitored in drinking water and any other organics for which a groundwater quality standard or criterion has been adopted.

35 Ill. Admin. Code § 811.319 (a)(2). Because Edison has operated Lincoln Quarry as a coal combustion waste monofill, and has fully characterized both the ash waste and the groundwater constituents derived from that waste, Edison is requesting that the Board limit the parameters for which Edison must conduct groundwater monitoring at the Site.

1. The Concerns Underlying the Monitoring Requirements in the Landfill Regulations Do Not Apply to Lincoln Quarry.

The groundwater monitoring program established under the Landfill Regulations is intended to ensure that constituents from waste deposited in a landfill do not migrate into and degrade groundwater. Where the wastes placed in a landfill vary significantly, as with a municipal landfill, or where the waste constituents or the constituent migration pathways are poorly characterized, it is important to monitor groundwater for a wide variety of parameters both to characterize the groundwater composition and to verify that constituents are not impacting the environment by leaching from the landfill. The Board's general landfill rules accomplish these objectives by requiring broad-based organic and inorganic constituent monitoring.

These concerns about waste characterization and variability do not apply to Lincoln Quarry, however, which has operated as a combustion ash monofill for over 20 years. As part of the testing that was performed in support of its Application, Edison evaluated the chemical composition of bottom ash and slag samples taken from both the Main Quarry and the West Filled Area. See, supra, pp. 23-24 and 27-28. This testing revealed that, over twenty years of Site operation, the composition of combustion wastes deposited in the Quarry remained generally consistent, although the specific percentages of each constituent in the ash varied somewhat from sample to sample. The ash samples contained primarily silicon, iron, aluminum, calcium, potassium, magnesium, sulfur, sodium, barium, and boron. See also, United States Environmental Protection Agency, Report to Congress Wastes from the Combustion of Coal by Electric Utility Power Plants, EPA/530-SW-88-002, § 3.2.1.5 at p. 3-15 (February 1988) ("Report to Congress") ("Over 95 percent of ash is made up of silicon, aluminum, iron, and calcium in their oxide forms"). Trace elements found in Edison's combustion waste include arsenic, cadmium, manganese, molybdenum, potassium, selenium, and zinc. See Exhibit 13 [Hydrogeological Report, Volume II Edison Application at p. HR-24 to HR-25]. None of the samples contained any of the organic constituents for which monitoring would be required under 35 Ill. Admin. Code § 811.319.[29] See Exhibit 13 [Hydrogeological Report, Volume II Edison Application at p. HR-24 to HR-25 and attached sampling data].

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[29] The Report to Congress also did not list any organic constituents among the typical components of combustion ash. Report to Congress § 3.2.1.5 at 3-15 through 3-22.

Harza confirmed the absence of organic parameters in Edison's combustion waste through groundwater sampling. In November 1992, Harza analyzed groundwater at the Site for those volatile and semi-volatile organic compounds that are listed on the Target Compound List or for which Illinois has promulgated Class I groundwater quality standards. This analysis found no volatile or semi-volatile organic parameters in the groundwater. See Hydrogeological Report, Volume II Edison Application at p. HR-26.

A protective groundwater monitoring program at such a Site should focus on those constituents that pose a potential risk to the environment and should not require monitoring for those constituents that are absent from the waste.

2. It Is Economically Unreasonable to Require Edison to Monitor Groundwater at Lincoln Quarry for Organic and Inorganic Constituents That Could Have No Environmental Impact.

Given that Edison's coal combustion waste contains no organic constituents, it is economically unreasonable to require Edison to monitor groundwater at Lincoln Quarry for organic parameters. Organic groundwater sampling and testing for all of the regulatorily required parameters would cost approximately $46,000 per year. By comparison, the ash sampling that Edison proposes below would cost only $1,000 annually, and would provide Edison with sufficient information about the organic composition of its combustion waste to predict whether this waste could impact Site groundwater. Thus, Edison should not be required to expend an additional $45,000 per year on organic chemical sampling to generate no environmental benefit.

Similarly, to analyze groundwater for all of the regulatorily required inorganic constituents would cost approximately $28,600 per year. By comparison, it would cost approximately $16,640 annually to analyze for only the potentially impacted parameters plus alkalinity at the Site, as proposed for Edison's adjusted standard. This more limited analysis would provide Edison with sufficient information about the inorganic parameters expected in its combustion waste and allow Edison to monitor Site impacts to groundwater. Thus, Edison should not be required to expend an additional $12,000 per year for inorganic chemical sampling that will result in no environmental benefit.

3. Description and Costs of Implementing Edison's Proposed Monitoring System.

Based on the ash and groundwater sampling results, Edison has proposed that the Board waive the requirement in 35 Ill. Admin. Code § 811.319 that Edison sample groundwater at Lincoln Quarry for organic constituents. Instead, Edison proposes annually to sample the combustion waste deposited in the Quarry for semi-volatile organic compounds, to verify that such compounds have not appeared in the waste. It is unnecessary to sample either groundwater or combustion waste for volatile organic compounds because the combustion process destroys any volatile compounds that might exist in the coal before burning. Only semi-volatile organic compounds potentially could remain in the bottom ash and slag. Consequently, Edison proposes annually to sample only for these semi-volatile parameters.

Edison also proposes to limit the frequency with which it must conduct groundwater sampling for inorganic constituents at the Site. On a quarterly basis, Edison proposes to monitor only those inorganic constituents for which it has detected statistically significant increases over background concentrations in downgradient monitoring wells. These constituents are:

Ammonia	Fluoride	Selenium	Total Organic Carbon
Arsenic	Manganese	Sodium	Zinc
Boron	Molybdenum	Sulfate	
Cadmium	pH	Total Dissolved Solids	
Chloride	Potassium		

For other inorganic constituents that fall within the terms of 35 Ill. Admin. Code § 811.319(a)(2), Edison proposes to perform annual sampling. Edison would conduct more frequent sampling for those inorganic constituents that are detected, through duplicate results, at levels of concern to the Agency. Once again, Site conditions, operations, and the type of waste disposed in the Quarry support this request for reduced monitoring.

The costs of monitoring under Edison's plan were discussed in section 2 above and compared to the costs for monitoring under the generally applicable standard. Edison believes its monitoring program will minimize monitoring costs while adequately protecting the environment.

4. Edison's Proposed Monitoring Plan Provides Environmental Protection Comparable to the Board's Generally Applicable Standards.

Edison's proposal to limit the constituents that it must monitor at the Site is based primarily on its knowledge about the composition of the bottom ash and slag deposited in the Quarry. This knowledge justifies eliminating organic chemical monitoring of groundwater and focusing inorganic monitoring on those potentially impacted parameters at the Site.

The organic and inorganic constituent concentrations in Site groundwater and ash waste have been well characterized and vary only minimally over time. Since organic constituent monitoring performed at the Site did not detect any organic contaminants in Site groundwater, Edison's monitoring proposal merely proposes to eliminate monitoring requirements for parameters that do not appear at the Site. If the constituents are absent, eliminating the monitoring requirement for those constituents would have no environmental impact.

With regard to inorganic constituent monitoring, Edison's two-tiered program focuses on those constituents that potentially could impact Site groundwater. The groundwater concentrations of inorganic parameters that originate at the Site are a function of the concentration of those constituents in the ash and the constituent's leaching potential. See Exhibit 13 [Hydrogeological Report, Volume II Edison Application at p. HR-26]. Both the constituent concentrations in, and the leaching potential from, the ash have been well characterized through sampling performed by Harza and have been consistent. Moreover, the groundwater concentrations of parameters attributable to the Site also have been consistent and predictable based upon ash concentrations. Given this high level of predictability, if previous monitoring results did not detect a particular inorganic constituent in Site groundwater, it is improbable that that constituent would appear in future sampling events. Similarly, for those inorganic parameters that have been detected at the Site, groundwater concentrations should remain constant or decrease over time as the leachable concentrations of those parameters in the ash decreases. Edison has proposed an alternative monitoring scheme for inorganic constituents that considers these factors.

Through six rounds of sampling, Harza has characterized the Site groundwater and has identified, by applying appropriate statistical techniques, certain potentially impacted parameters, listed above, which currently have a minimal but statistically significant increase over background groundwater concentrations. See Exhibit 13 [Hydrogeological Report, Volume II Edison Application at p. HR-34 through HR-37]. Presuming that these increased concentrations are attributable to Site activities, Edison has proposed to monitor these parameters on a quarterly basis. For other inorganic constituents, Harza either did not detect the parameters in the groundwater or found no statistically significant increase in parameter concentrations over background levels. Edison has proposed to monitor these inorganic constituents annually, merely to verify that the groundwater composition remains consistent, within the limits of statistical variability.

Where constituent concentrations in the waste vary only minimally, and where sampling and statistical analyses have revealed no significant impact on groundwater for certain parameters over 20 years of operation, any adverse environmental impact to be expected from annual, rather than quarterly, monitoring for those constituents would be negligible. Consequently, for the Lincoln Quarry Site, Edison's proposed monitoring program provides adequate environmental protection.

5. Summary.

Because the ash waste deposited at Lincoln Quarry is uniform and the potentially impacted groundwater parameters have been readily identified, Edison requests that the Board approve an alternative groundwater monitoring proposal, which focuses on the potentially impacted parameters and eliminates monitoring requirements for constituents that are not found at the Site.

G. MONITORING WELL LOCATION

Section 811.318 of the generally applicable landfill standards establishes location standards for wells in a monitoring well network. Under this section, Edison must place wells "at sufficient locations downgradient with respect to groundwater flow and not excluding the downward direction, to detect the discharge of constituents from any part of a potential source of discharge." 35 Ill. Admin. Code § 811.318 (b)(1). At least one of these wells must be located at the edge of the zone of attenuation (100 feet from the waste boundary). Additional wells must be placed: as close as possible to the waste boundary; and within half the distance between the edge of the potential discharge source and the downgradient edge of the zone of attenuation (50 feet from the waste boundary). 35 Ill. Admin. Code §§ 811.318 (b)(3) and (b)(5).

Although Edison can establish a network of groundwater monitoring wells that protects the environment at Lincoln Quarry, physical constraints prevent Edison from installing large numbers of monitoring wells or wells within the distances specified in the landfill regulations. In particular, if the Board adjusts the zone of attenuation for the Site, as requested in this Petition, Edison will be unable, because of physical constraints at the Site, to place a monitoring well at the edge of the adjusted zone. For these reasons, Edison is requesting an adjustment of the monitoring well location standards.

1. <u>The Board's Monitoring Well Location Standards Did Not Consider Conditions At the Lincoln Quarry Site.</u>

In setting its well location standards, the Board stated that groundwater monitoring is intended to "detect any discharge of contaminants from any part of a potential source of discharge." 35 Ill. Admin. Code § 811.318 (b)(1). The Board applied leachate flow models for two different lined landfills situated in natural soil deposits and subject to fairly low groundwater flow rates to determine the appropriate location for monitoring wells to meet its objectives. See Landfill Recommendations at 76. Based on these models, the Board determined that equally-spaced monitoring wells located radially on the downgradient side of the landfill, at or within 100 feet from the waste boundary (the generally applicable zone of attenuation), would provide an optimal groundwater monitoring network at most sites. The Board's general landfill standards incorporate this conclusion.

While the Board's conclusion about monitoring well locations applies to the types of landfills modeled by the Board, it does not apply to Lincoln Quarry since conditions at the Quarry undercut several critical assumptions supporting the Board's models. For instance, the Board's models assumed that regulated landfills are lined and are situated in porous media, such as natural soil deposits or granular, porous rocks. In such media, groundwater flow rates and physico-chemical processes of soil attenuation are consistent and can be modeled for the entire system based on limited flow volumes. Groundwater moves through evenly distributed open pore spaces in the soil matrix at a rate that is determined by the soil's permeability and its effective porosity, and by the hydraulic gradient. In Illinois, such flow velocities tend to be relatively slow and consistent for landfills because the clay liners and soils tend to have low permeability. In addition, constituent concentrations in groundwater flowing through porous media tend to decrease through attenuation as the constituent plume moves further from the waste source. NSWMA, Initial Responses to Comments: Proposed Parts 810 through 812, R84-17, Docket D (June 29, 1987).

In contrast to the Board's model, Lincoln Quarry is located in fractured dolomitic rock. Virtually no groundwater flow occurs in the unfractured, impermeable bulk of the rock mass; however, groundwater does flow through secondary porosity features, like discrete rock fractures and bedding planes. Groundwater properties within these distinct features reflect localized conditions that cannot be generalized to the rock mass. Where fractures transect the rock mass to form a series of interconnected flow paths, the channels usefully can be examined on a large scale to derive some predictions about the operation of the groundwater system. From such large-scale analysis, it appears that, although groundwater flow rates through the rock mass at Lincoln Quarry taken as a whole are very slow, groundwater flow rates within individual fractures and bedding planes can be very rapid.

Geochemical processes of attenuation also are of little or no significance at Lincoln Quarry. The degree to which attenuation and hydrodynamic dispersion occur depends upon the occurrence of discontinuities in the rock, as well as the properties, orientation, and degree of interconnection of those discontinuities. Although discontinuities do exist in rock at Lincoln Quarry, there is little or no interaction between the chemical constituents and the bulk of the rock mass.

Consequently, little or no attenuation occurs between monitoring wells close to the waste boundary and wells located further from the waste edge.

These dramatic differences between the Board's landfill model and the conditions at Lincoln Quarry require different groundwater monitoring approaches for each type of Site. In order for a groundwater monitoring system accurately to reflect Site conditions, that system must presume that discrete sampling points taken at the Site are representative of the larger volume of water bearing material. This presumption is valid on the small scale for the type of porous material considered in the Board's model. Thus, establishing monitoring wells at or within 100 feet from the waste boundary, as required by the Landfill Standards, is likely to give an accurate picture of constituent transport at the type of site considered by the Board. See Landfill Recommendations at 76.

For the fractured flow media at Lincoln Quarry, however, groundwater monitoring can present an accurate picture of constituent transport only if it is conducted on a large scale. A careful evaluation of Site conditions indicates that placement of the groundwater monitoring wells at or near the location prescribed by Board's standard will fail to provide useful monitoring data for the Site. Instead, Edison proposes to locate monitoring wells beyond the regulatory 100-foot standard and within the North Quarry. See Exhibit 13 [Figure SAP-5 to the Sampling and Analysis Plan, Volume II Edison's Application].

2. Because of the Terrain Surrounding Lincoln Quarry, Installation of a Monitoring Well System That Complies with the Board's Landfill Standards Would Be Technically Impracticable and Economically Unreasonable.

It is technically impracticable for Edison to satisfy the well location standards contained in 35 Ill. Admin. Code § 811.318 under either the generally applicable or the adjusted zone of attenuation. Within 100 feet downgradient of the Main Quarry boundary (the zone of attenuation under the Board's regulations), the Site contains: Edison's screening berms and security fencing; a strip of land just wide enough to support Patterson Road (a two-lane public access road); the sheer vertical dolomite faces of both the Main and the North Quarries; and deep ponds within the North Quarry. It is technically impracticable for Edison to locate a network of monitoring wells within these site features. Most significantly, the narrow strip of land between the Main and North Quarries provides insufficient access for well drilling equipment and personnel to install a well, raising concerns about employee safety. Even if Edison could access sufficient space within this region for one well, the Company would be unable to locate a network of secure wells in this area, as required by the regulations.

It also is questionable whether wells located in this region would provide accurate, reliable, or meaningful monitoring data. Most of the region has been disturbed through quarrying or other land use activities. These activities affect the geology within this area, thereby altering local groundwater flow patterns. Also, because of the differences in hydraulic gradients between the Main and North quarries, the groundwater flow in this area is atypical by comparison to the rest of the Site.

Thus, even if Edison could locate wells within this region, it is doubtful that those wells would provide any meaningful information about constituent migration or groundwater flow. Where the value of the data to be obtained from these wells is dubious, it would be economically unreasonable to required Edison to expend additional capital installing and monitoring such wells.

It also would be technically impracticable for Edison to locate wells at the edge of the adjusted zone of attenuation proposed in this Petition. The adjusted boundary for the zone of attenuation would be contiguous with the northern-most property boundary for the site. However, this property boundary is located at, or sometimes beyond, the banks of the Des Plaines River. This location provides inadequate access for well drilling equipment and personnel to install a well. Because mixing between the groundwater and water from the Des Plaines River also occurs within this area, it is questionable whether monitoring wells located in this region would accurately reflect groundwater concentrations for the constituents of concern.

Even if Edison were able to install monitoring wells at the locations prescribed by the Board's standards, installation of such wells would require significant expenditures. To meet the Board's standards would necessitate installation of approximately 30 additional groundwater monitoring wells for the Site at an estimated cost of $10,000 per well, for a total expense of $300,000. This cost is unreasonable in light of the minimal environmental benefit to be expected from monitoring such additional wells.

3. Description, and Cost Estimates, for Installation of Edison's Proposed Monitoring Well Network.

Edison has proposed that the Board allow Edison and the Agency to develop a mutually agreeable monitoring well network for the Lincoln Quarry Site that takes into account unique Site conditions. As a starting point for such network, Edison intends to propose use of the following ten pre-existing wells in six Site locations:

- Upgradient wells 92-2S and 92-2D located south of the Quarry.
- Downgradient wells:
  - Nested wells R08S and R08D located northwest of the Quarry;
  - Nested wells 92-5S and 92-5D located north of the Main Quarry;
  - Nested wells G20S and R16D located near the northeast corner of the Quarry;
  - Well 93-9 located north of the Quarry near the Des Plaines River; and
  - Well 93-11 located northwest of the Quarry near the Des Plaines River.

These well locations are depicted on Exhibit 13 [Figure SAP-5 to Sampling and Analysis Plan, Volume II Edison's Application]. Edison has expended approximately $60,000 to install these wells. Based on experience with wells at these locations, Edison believes that this monitoring well network, or a similar network approved by the Agency, will accurately track constituent migration through groundwater at Lincoln Quarry.

4. Edison's Proposed Monitoring Well Network Adequately Protects the Environment While Satisfying the Objectives of the Board's Current Monitoring Regulations.

By comparison to the monitoring well network required by the Board's standards, Edison's proposed monitoring well network, or a similar network proposed by the Agency, would provide a comprehensive and accurate picture of constituent migration at the Lincoln Quarry Site.

Because of hydrogeologic conditions at the Site, it is more important, from an environmental perspective, to track constituent migration through groundwater under the North Quarry, located several hundred feet from the edge of the Main Quarry, than at 100 feet from the Main Quarry waste boundary, as required under the generally applicable regulations, or at the northern property boundary under the proposed adjusted zone of attenuation. As explained in the Background section of this petition [See, supra, pp. 33-44], the Des Plaines River is the only significant environmental receptor for groundwater from the Site. To determine the concentration of groundwater constituents migrating to the Des Plaines River, Edison must install monitoring wells in locations that will accurately reflect groundwater flow to the River, without mixing this flow with River water. Monitoring wells installed at or within 100 feet of the Main Quarry waste boundary, or at the northern property edge, will not achieve the desired results.

Only a small fraction of the groundwater at the Site (1.4 percent of the daily total) actually flows directly to the Des Plaines River. Most of the groundwater, along with surface water, flows from the Main Quarry to the settling pond in the North Quarry under the influence of a hydraulic gradient generated in part by Edison's pumping activities. The small fraction of water that bypasses this pumping system comprises the only groundwater outflow from the Site. A Site groundwater monitoring well network should be used to monitor the constituent concentrations in this groundwater, since it is this outflow that directly reaches the Des Plaines River. Monitoring wells installed 100 feet from the Main Quarry waste boundary provide no information about this outflow but, instead, track water flowing from the Main Quarry to the North Quarry settling pond. Monitoring wells located at the northern property boundary of the Site will detect both groundwater and River concentrations of constituents in an unpredictable mixture. By establishing a monitoring well network at distances greater than 100 feet from the waste boundary but within the property boundary, Edison can more effectively and comprehensively monitor the relevant groundwater flow parameters at the Site. Because Edison's groundwater monitoring program is based on extensive characterization of actual Site conditions, it satisfies the Board's environmental objectives of monitoring environmentally relevant constituent flow at the Site.

5. Summary.

In light of the unique groundwater flow conditions at Lincoln Quarry, Edison requests that the Board allow Edison and the Agency to develop a mutually agreeable monitoring well network for the Lincoln Quarry Site that takes into account unique Site conditions.

H. ZONE OF ATTENUATION.

The generally applicable landfill standards define the zone of attenuation as "a volume bounded by a vertical plane at the property boundary or 100 feet from the edge of the unit, whichever is less. . ." 35 Ill. Admin. Code § 811.320(c). This zone provides a compliance boundary for the waste disposal unit. Within this zone of attenuation, some groundwater degradation is permitted and groundwater is subject to the Class II groundwater quality standards. 35 Ill. Admin. Code §§ 620.420, 620.440. At or beyond the zone of attenuation, the Board has implemented a non-degradation policy, requiring that groundwater quality be maintained "at each constituent's background concentration," as determined by groundwater quality monitoring upgradient of the facility. 35 Ill. Admin. Code § 811.320.

1. In Defining the Generally Applicable Zone of Attenuation, the Board Did Not Consider Water Flow Conditions Like Those Present at the Site.

As discussed above in Section G.1., in defining the generally applicable groundwater monitoring well network and the applicable zone of attenuation, the Board applied flow models to lined landfills situated in natural soil deposits and subject to fairly low groundwater flow rates. See Landfill Recommendations at 76. Constituent concentrations in groundwater flowing through such porous media tend to decrease through attenuation or hydrodynamic dispersion as the constituent plume moves further from the waste source. Attenuation refers to several chemical/physical/biological processes that tend to reduce constituent concentrations over time, including: absorption, adsorption-dissolution, complexing, dilution, ion exchange, ion filtration, precipitation-dissolution, and biological and chemical degradation. NSWMA, Initial Responses to Comments: Proposed Parts 810 through 812, R84-17, Docket D (June 29, 1987). Hydrodynamic dispersion involves the physical processes of mechanical mixing and molecular diffusion. As a constituent plume moves away from a source, hydrodynamic dispersion causes that plume to expand, increasing the volume of affected groundwater while the actual mass of the constituents in that volume remains the same. Both attenuation and hydrodynamic dispersion tend significantly to reduce groundwater constituent concentrations with time and distance from the source.

Based on conclusions from models in porous media, the Board established the generally applicable 100 foot zone of attenuation as the distance within which groundwater constituent concentrations should reach background levels through natural processes of attenuation. However, groundwater models predicting attenuation of constituents in porous media do not apply to Lincoln Quarry. As discussed above in Section G.1., Lincoln Quarry is located in fractured rock, with virtually no groundwater flowing through the unfractured rock mass. While groundwater flow rates through the rock mass generally are very slow, groundwater flow rates within individual fractures and bedding planes at Lincoln Quarry can be very rapid. The degree to which attenuation and hydrodynamic dispersion can occur under these conditions depends upon the existence, number, properties, and relationship between discontinuities in the rock mass. In general, however, geochemical processes of attenuation are of little or no significance at Lincoln Quarry because there is little or no interaction between the chemical constituents and the rock mass.

This predicted lack of attenuation is reflected in groundwater measurements taken by Harza. For example, in well G08S about 200 feet from the West Filled Area, boron was found at a concentration of 6.16 mg/L. Similar boron concentrations were found in well 93-12 (6.54 mg/L) at 500 feet from the ash limits and in well 93-11 (6.36 mg/L) at more than 800 feet from the ash limits. As these measurements reflect, for the groundwater parameters of concern at the Site, constituent concentrations in groundwater measured at the waste boundary are equivalent to concentrations measured in wells located near the discharge zone to the Des Plaines River.

2. Retaining the Zone of Attenuation at the 100 Foot Boundary Would Cause Edison to Incur Tremendous Expense for Minimal Environmental Benefit.

Because of the lack of attenuation at the Lincoln Quarry Site, some minimal groundwater degradation over background concentrations already has occurred beyond the Main Quarry's applicable 100-foot zone of attenuation for the following parameters:

Ammonia	Fluoride	Selenium	Total Organic Carbon
Arsenic	Manganese	Sodium	Zinc
Boron	Molybdenum	Sulfate	
Cadmium	pH	Total Dissolved Solids	
Chloride	Potassium		

This degradation began well before enactment of the standard establishing the zone of attenuation and is primarily attributable to the disposal of flyash in the inactive West Filled Area. Even if Edison took additional precautions with regard to, or halted, current disposal activities, groundwater downgradient of the Site beyond the 100 foot zone of attenuation would continue to exceed the Board's non-degradation standard, particularly for boron and sulfate. As a practical matter, then, it is technically impracticable to establish the zone of attenuation as required by the generally applicable standards.

It would be possible for Edison to address groundwater exceedances from future activities through alternative disposal options; however, these potential disposal options are prohibitively expensive and promise only negligible environmental benefit. Edison examined numerous alternatives for bringing the Lincoln Quarry Site into partial or complete compliance with the groundwater standards at the edge of the zone of attenuation, including:

- Converting the facility from sluiced to dry disposal and constructing a new landfill on the existing ash that would be designed in compliance with the standards in part 811;
- Closing the landfill and contracting for off-site ash disposal at existing facilities;
- Closing the landfill and the generating stations; or
- Closing the landfill and constructing a new off-site landfill for ash disposal.

The activities necessary to implement each of these proposals, as well as the estimated costs, are described as part of the closure options in Exhibit 12. Generally, all of the available options present severe adverse economic and/or social impacts for limited, if any, environmental benefit. Under the first option, the Main Quarry would remain operational, providing disposal capacity for the Joliet Stations for the foreseeable future. Under the remaining three alternatives, the existing landfill would be closed and alternative means for disposing of the bottom ash would be utilized, including off-site disposal at an existing ash landfill, construction of a new landfill, or closure of the Stations. Each of these options present serious economic, community, and potential environmental consequences.

Furthermore, although the available options for ongoing operations prevent groundwater impacts from future disposal activities at the Site, they do not address impacts from prior waste operations, which account for many of the exceedances at the edge of the zone of attenuation. Concentrations of those parameters that exceed the Board's groundwater standards will remain stable or decrease with time and would not change significantly upon immediate closure of the Site. For these reasons, an adjusted the zone of attenuation would be necessary to address existing constituent concentrations in groundwater.

To reduce such existing concentrations, Edison could excavate the material currently contained in the Main Quarry and the West Filled Area and dispose of this material offsite. Costs for such excavation and disposal are estimated to range between $65 million and $187 million, while the environmental benefits from such excavation would be minimal. See Exhibit 12, option 7. Alternatively, Edison could install a leachate/groundwater collection system, as discussed above. Again, there would be no environmental benefit from such a system, because the groundwater collected by Edison, without treatment, would satisfy NPDES discharge standards for, and would be pumped directly to the Des Plaines River. It is economically unreasonable to require Edison to install such a groundwater collection system when the net effect of such a system would be merely to reroute the River discharge to an alternative location.

3. Description and Cost Estimate for Edison's Proposed Extension of the Zone of Attenuation.

As a practical compromise to address Site conditions which do not allow for attenuation of groundwater constituents, Edison proposes that the Board adjust the downgradient zone of attenuation to the northern property boundary of the Site adjacent to the Des Plaines River, approximately 1,000 feet from the waste edge. This proposal is consistent with Board's approach under its current definition of "zone of attenuation," which, in some cases, sets the edge of the zone at the property boundary.

When coupled with the adjusted monitoring well location standards discussed in Section G and the agreement with IEPA to establish a groundwater management zone ("GMZ") at the Site, this proposal provides a mechanism for consistent and comprehensive treatment of Site conditions. First, the proposal places all relevant site features that potentially contribute to elevated constituent concentrations in groundwater within a single zone of attenuation for the Site. Second, it makes this zone of attenuation contiguous with the GMZ proposed by IEPA. Through ongoing negotiations, IEPA has agreed to designate the Lincoln Quarry Site from the waste boundary to the site boundary as a GMZ, pursuant to 35 Ill. Admin. Code § 620.250. This GMZ will address elevated levels of groundwater constituents at the Site by requiring Edison to monitor constituent concentrations in groundwater within the GMZ and to implement institutional controls. By extending the zone of attenuation to the northernmost property boundary, the Board will facilitate cooperative and comprehensive management of elevated groundwater concentrations.

4. Edison's Proposed Extension of the Zone of Attenuation Adequately Protects the Environment.

Current constituent concentrations in groundwater at the Site have no discernable impact on water quality in the Des Plaines River, the only relevant environmental receptor affected by the increase in the zone of attenuation. The

Background Section of this petition, supra, and Exhibits 3 through 9, address the results of groundwater quality monitoring that was performed at the Lincoln Quarry Site. This monitoring demonstrates that, for the potentially impacted parameters, the environmental impacts from ongoing groundwater discharges to the River are negligible. For each potentially impacted parameter, the contribution to the River concentration of that constituent attributable to groundwater discharges from the Site, even during low flow periods, falls well within the expected natural variation of the River concentration (as approximated by the standard deviation of mean River concentrations). As a practical matter, this means that the concentrations of groundwater constituents discharged from the Site are indistinguishable from natural incremental deviations in the River concentrations of those constituents. See Exhibits 7-8. Moreover, the Site contributions to River concentrations are several orders of magnitude smaller than the changes in River concentrations that actually could be detected using current analytical methods. See Exhibit 7 (Method Detection Limits for the potentially impacted parameters). Thus, current discharges from the Site have no impact on River concentrations of constituents.

In addition, extending the zone of attenuation to the northern-most property boundary at the Site will have no environmental impact on the region between the current and the proposed zones of attenuation. As discussed in the Background section above, there are no current uses for impacted groundwater downgradient of the Site. Future use of this groundwater also is unlikely, because:

- Edison owns or controls most of the land between the Quarry and the River and has no plans to develop groundwater wells on this land, which lies within the minimum setback zones established by the Illinois Groundwater Protection Act.

- The land surrounding and downgradient of the Quarry is industrialized and unsuitable for residential development; and

- The unimpacted deeper aquifers below the Maquoketa Shale aquitard provide a more secure and plentiful groundwater resource than the shallower aquifer impacted by Edison's activities. Any development that might occur most likely would exploit this plentiful water resource.

Consequently, Edison's proposed zone of attenuation does not impact any known or potential environmental receptors.

5. Summary.

Edison urges the Board to adopt the adjusted standard to extend the zone of attenuation because the standard adequately protects the environment and because compliance with the generally applicable standards is technically impracticable, economically unreasonable, and environmentally unnecessary.

I. FINAL COVER REQUIREMENTS.

Section 811.314 prescribes a two-stage system of final cover, consisting of a low permeability layer and a final protective layer. Under this section, an appropriate low permeability layer must perform as well as a three-foot thick layer of earth that has been compacted to minimize void spaces and to achieve a permeability of 10^{-7} centimeters per second. Such a layer may consist of compacted earth, a geomembrane placed over a base free from sharp objects, or any other similarly performing material. The final protective cover of soil must be at least three feet thick, must be capable of supporting vegetation that will minimize wind and water erosion, and must protect the low permeability layer.

1. The Board's Generally Applicable Cover Requirements Do Not Apply to Conditions At Lincoln Quarry.

The Board promulgated the cover requirements of the general landfill standards to meet the following environmental objectives:

- minimization of water percolation and infiltration into the waste;
- control of water run-off from the cover;
- maximization of evapotranspiration;
- controlling landfill gas; and
- prevention of cover erosion and minimization of maintenance.

See Landfill Recommendations at 54. The Board has recognized, however, that from a technical perspective, these objectives often are in tension with one another. For instance, "a cover designed to minimize infiltration is likely to have a high erosion potential because the fine clay particles necessary for a low permeability blanket are susceptible to wind and water erosion and may be difficult to vegetate." Landfill Recommendations at 54.

To minimize these tensions and maximize the environmental benefits to be derived from a final cover system, the Board, under section 811.314, required all landfills to install a multi-layer composite cover, in which each layer possesses unique characteristics that achieve one or more of the generally applicable environmental goals. Landfill Recommendations at 54. The low-permeability earth layer or the geomembrane layer minimizes infiltration and percolation of water to the waste. The final 3-foot thick protective layer of well-graded, easily drained soils and vegetation prevents erosion of the cap, effectively channels water run-off, and maximizes evapotranspiration. For most landfills, this multi-layer cover system achieves the desired environmental benefits.

However site hydrogeologic conditions at Lincoln Quarry render inapplicable many of the environmental justifications for a multi-component cover. These environmental justifications and their impacts at the Site are discussed in turn.

a. Minimization of Water Percolation and Infiltration into the Waste

Given the hydrogeologic setting of Lincoln Quarry, there is no environmental benefit to be gained by installing a cover system that controls or minimizes surface water access to the landfill. Control of water infiltration into landfill waste is intended to reduce the amount of leachate that a landfill generates. The amount of leachate that is generated depends in part on the amount of water that reaches the waste. The generally applicable cover system significantly limits water access to waste at most landfills by controlling the predominant pathways for water to reach landfilled materials: infiltration or percolation through the landfill cap and the waste; run-off to the landfill surface; and insufficient evapotranspiration from the landfill surface. Landfill Recommendations at 54.

At Lincoln Quarry, however, the volume of water reaching and remaining in the Quarry through these pathways is trivial compared to the volume of natural groundwater that flows into the Quarry. Lincoln Quarry is an unlined dolomite quarry with vertical rock walls that extend well below the natural groundwater table. Fractures in these walls provide pathways for groundwater from the south and east to migrate into the Quarry. The rate at which this groundwater flows into the Quarry is proportional to the inward hydraulic gradient which, in turn, is proportional to the difference between the water level in the Quarry and the level of the adjacent groundwater table. If the water level in the Quarry is lowered, both the difference between the Quarry level and the natural groundwater level, and the volume of inflow into the Quarry, increase.

As part of its ash disposal operations, Edison maintains a substantial inward groundwater gradient at Lincoln Quarry by releasing water from the Main Quarry into the North Quarry. Because of this gradient, groundwater flows into the Main Quarry at a rate of about 600,000 gallons per day ("gpd") according to field investigations. Groundwater will continue to flow into the Quarry at a substantial rate if Edison maintains the water level in the Quarry below the level of the surrounding natural groundwater table. Even if the Quarry water level and the level of the groundwater table equalize, groundwater will still flow into the Quarry at a high rate because the natural groundwater flow in the area is from the south through the Quarry to the Des Plaines River. Finally, groundwater inflow into the Quarry would continue despite any final cover that might be constructed.

A cover system for Lincoln Quarry would reduce, but not eliminate, the amount of water that reaches the bottom ash and slag due to precipitation. However, the environmental benefit to be gained from such a cover system would be minimal. The vast bulk of the water that reaches the waste does so as groundwater inflow from the Quarry walls. Such groundwater inflow would be unaffected by a cover system.

b. Control of Water Run-Off from the Cover.

As long as the level of waste in the Main Quarry is below the Quarry rim, the Board's generally applicable cover system would not control run-off at Lincoln Quarry, because the cover would be constructed below the top of the Quarry walls and could not be contoured to provide natural drainage. To achieve drainage, Edison would be required to install an elaborate run-off collection and pumping system to remove water that accumulates at the junction of the cover and the Quarry walls.

c. Maximization of Evapotranspiration.

Under the generally applicable standards, maximizing evapotranspiration from the cover is intended to further reduce the amount of water infiltration to the waste. This concern does not apply to Lincoln Quarry because the majority of the water reaches the waste through groundwater inflow rather than as precipitation.

Currently, the water level in the Main Quarry is above the ash level. In this situation, water reaches the ash by two primary routes: direct precipitation to the Quarry pond surface, less evaporation; and groundwater inflow from the Quarry walls. Approximately 91,062 gpd total of direct precipitation reaches the Quarry pond surface. Of this total, approximately 89% evaporates from the open Quarry, leaving about 10,118 gpd of precipitation that reach the ash waste (estimated by subtracting normal annual lake evaporation of 32 inches[30] from normal annual precipitation of 36

[30] Wyndam and Stall, Lake Evaporation in Illinois, Illinois State Water Survey Report of Investigation, at p. 57 (1967).

inches[31]). On a daily basis, this amounts to only 0.87 fluid ounces of water per square foot of the pond surface. At the same time, the estimate groundwater inflow rate to the Main Quarry is 600,000 gpd. Thus, the net amount of water contributed to the uncovered Quarry by precipitation is minimal compared to groundwater inflow (1.7 percent of the estimated groundwater inflow rate). This small amount of precipitation that reaches the waste represents the maximum additional leachate volume that could be generated if Edison failed to cap the Quarry. The effect of this additional leachate on downgradient groundwater quality would be undetectable.

d. Control of Landfill Gas.

As a monofill, Lincoln Quarry contains only non-putrescible industrial wastes consisting of various inorganic constituents, principally oxides of silicon, aluminum, iron, and calcium. Because the wastes contain no organic constituents that might produce gases through decomposition, the Board's cover system is unnecessary to control landfill gas.

e. Prevention of Cover Erosion and Minimization of Maintenance.

The cover system mandated by the Board would require significant upkeep and maintenance. Because of hydraulic conditions at the Site, there is a significant possibility that the cap would degrade under uplift pressures caused by groundwater flow into the landfill. Thus, Edison would be required, with or without a cap, to manage the piping, settling pond, and pumps used for discharge control to the

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[31] Wendland, Mean 1961-1990 Temperature and Precipitation over the Upper Midwest. (Midwestern Climate Center, Champaign, Illinois 1992).

Des Plaines River. In addition, under the Board's required cover, Edison must take added measures to ensure that the cap does not degrade under pressures caused by groundwater inflow.

2. It Would Be Technically Impracticable and Economically Unreasonable to Install a Final Cover System Satisfying the Generally Applicable Requirements for the Main Quarry.

Under the Board's generally applicable landfill standards, two compliance alternatives exist to satisfy the final cover requirements:

- Option 1 - install a compacted earth low-permeability layer covered by three feet of soil; or
- Option 2 - install a geomembrane liner covered by three feet of soil.

Neither option is reasonable or practical for closure of Lincoln Quarry.

a. Wet Closure.

The adequacy, technical feasibility, and economic reasonableness of any cover system at Lincoln Quarry must be evaluated in light of the hydrogeologic conditions existing at the Site. At the current disposal rate, Edison estimates that the ash level in the Main Quarry will not reach the natural water level during the remaining operating life of the Joliet Stations. As a result, Edison believes that closure of Lincoln Quarry is most likely when the level of ash in the Quarry is below the natural water table.

In the event of wet closure, it would be technically impracticable and economically unreasonable for Edison to install a multi-layer final cover like the one required by the generally applicable landfill standards. To construct such a cover under the wet-closure scenario, Edison would be required to dewater the Quarry and to continue dewatering operations in perpetuity to insure the integrity of the cover. As described above at pp. 54-55, dewatering the Quarry before construction at a rate of approximately 8,750,000 gallons per day or 5,700 gallons per minute would require at least 30 days and would cost about $150,000 for operations and maintenance, and about $2.0 million for a grout curtain or $2.42 million for a slurry wall. Dewatering would continue during construction to remove groundwater flowing into the Quarry through fractured landfill walls. It is estimated that total operation and maintenance costs for the construction dewatering effort would be between $500,000 and $ 600,000.

After the Site had been dewatered, construction of the cover could begin. Assuming that option 1 has been selected, considerable amounts of soil would be required to construct the compacted-clay cover because the Main Quarry has a surface area of roughly 208,000 square yards. To begin with, the deposited ash would be regraded to provide a working surface for cover material. Then, a drainage blanket would be required to keep the Quarry dewatered because, as a fine-grained, low-permeability material that drains slowly, the bottom ash cannot be fully relied upon safely to drain excess water from beneath the cover. A drainage blanket large enough to handle the estimated volumes of groundwater inflow would require 70,000 cubic yards of gravel, at a unit cost of $19.09 per cubic yard and 416,000 square yards of filler fabric at a unit cost of $2.70 per square yard, for a total cost of $2.45 million.

To install a three-foot thick compacted-clay, low-permeability layer, Edison would need 208,000 cubic yards, or approximately 21,000 truckloads, of clay. A similar quantity of soil would be required to install the protective layer. Because sufficient fill material does not exist at the Site to meet these requirements, Edison would need to purchase the material and import it from another source. Assuming unit costs of $14.33 per cubic yard for clay and protective layer soil (including transportation), the materials for the cover alone, including top soil and seeding, would cost $6.4 million. See, generally, Exhibit 12. Moreover, transportation of this material to the Site and construction of this cover would require considerable time and result in significant disruption for surrounding residential areas.

Construction of the cap itself also would pose significant difficulties. Edison would be required continuously to dewater the landfill both during construction and to prevent ponding of water on constructed portions of the cap. In addition, the construction contractor would need to manage between 25 and 30 trucks per hour on a regular basis for about 8 months while the fill is being placed.

Rather than installing a compacted earth layer, Edison could reduce the amount of soil that would be required by using a geomembrane liner under Option 2. Installation of 208,000 square yards of liner, at a unit cost of $4.50 per square yard, would cost $940,000. See, generally, Exhibit 12. In addition, approximately 277,000 cubic yards of soil [one foot as liner base and a 3-foot protective layer] still would be required for the final cover, at a cost of $3.97 million.

Once the cover is in place, perpetual dewatering would be required to maintain the water level in the landfill below the minimum elevation of the cover, thereby guaranteeing the cover's integrity. In connection with its landfilling operations, Edison pumps water from the Main Quarry into the North Quarry settling pond. This pumping reduces the water level in the Main Quarry below the natural groundwater level in the adjacent bedrock, causing the Quarry to act as a groundwater sink. If Edison stops pumping water from the Quarry, the water level in the Quarry will rise to the natural groundwater level. As long as the ash level in the Quarry at closing is below this natural groundwater level, Edison must continue dewatering the ash to protect the cover from inflowing groundwater and resulting hydrostatic [uplift] pressures. If Edison ceases its dewatering effort, the cover will fail either locally or totally, resulting in the development of local surface seeps on a small scale or the uplift or flooding of larger portions of the cover.

The total costs of "wet closure" in compliance with the cover requirements would be $20.3 million [off-site disposal] or $27.5 million [constructing a new facility], as discussed under Exhibit 12, Options 6B and 6C respectively.

b. Dry Closure.

If Edison continues to operate the Quarry until the level of bottom ash and slag exceeds the level of the natural water table, it would be feasible for Edison to install the cap required by the generally applicable landfill rules without performing extensive dewatering. Such installation would be economically unreasonable, however, in light of the minimal environmental benefits to be expected. Furthermore, given the large remaining disposal volume in the Quarry, closure under this scenario is extremely unlikely.

As with premature closure, two compliance alternatives exist under the generally applicable regulation: installing a compacted earth low-permeability layer covered by three feet of soil; or installing a geomembrane liner covered by three feet of soil. Although significant dewatering would not be necessary for construction of the cap, a drainage blanket over a large area still would be necessary to protect the final cover. In addition, Edison still would be required to purchase large amounts of suitable cover material and transport the material to the Site. The total costs of "dry closure" in compliance with the cover regulations would be $7.5 million, and consist of the elements discussed under Exhibit 12, option 5A.

3. Description of, and Cost Estimates for, Edison's Adjusted Closure Requirements.

Exhibit 12 discusses a variety of alternative cover options that Edison considered to satisfy the Board's generally applicable landfill standards. Based on its evaluation of these options, Edison concluded that the Board's cover system generally is technically impracticable and economically unreasonable for installation at Lincoln Quarry. Instead, Edison proposes the alternative cover options discussed below that are technically feasible, cost-effective, and protective of the environment. These cover proposals are detailed more fully in Exhibit 13, the "Closure and Post-Closure Care Plan," submitted as Appendix F, Volume III to Edison Application.

As discussed above, if, at the time of closure, the ash level in the Main Quarry is below the water level for the groundwater table, Edison would close the landfill in its present "wet" condition (the most likely closure option). Edison would install a fence to prevent access to the Quarry and would monitor the fence on a regular basis. The amount of water passing through the impoundment would decrease significantly as the sluicing of ash stops. Edison would maintain the water level in the

Quarry at a level that supports the present inward hydraulic gradient. Water would be discharged from the North Quarry settling pond to the Des Plaines River pursuant to Edison's NPDES permit. Edison suggests that this approach is most feasible considering Site conditions, is least costly, and will provide comparable environmental benefits as Board's final cover at this Site. This proposed closure plan is discussed in more detail in Exhibit 13, Appendix F, Volume III Edison Application at pp. CP-4 through CP-5.

The estimated costs for this closure option would be:

Capital Costs

Fence, regrading ash above water level, and erosion controls	$ 500,000
Subtotal	$ 500,000

Annual Operation and Maintenance Costs Through 2015

Existing Water Handling System	$ 142,000
Groundwater Monitoring	$ 50,000
NPDES	$ 5,000
Subtotal	$ 197,000

Annual Post Closure Care Costs

Inspection	$ 5,000
Existing Water Handling System	$ 10,000
Groundwater Monitoring	$ 50,000
NPDES	$ 5,000
Subtotal	$ 70,000

TOTAL PRESENT VALUE COSTS	$3,660,000

See Exhibit 12, option 1A.

If, at the time of closure, the level of ash in the Main Quarry is above the natural groundwater table for the surrounding areas, Edison proposes to install a two-stage cover system, consisting of a compacted clay layer that performs equivalently to 2 feet of compacted soil having a hydraulic conductivity of 1 x 10^{-7} cm/sec, overlain by at least four inches of topsoil. The cap would be sloped at no less than a two percent grade and would be seeded to prevent erosion.

Surface run-off and precipitation would drain to a collection area constructed on the cap. A drainage blanket would underlie this collection area. Water accumulated in this collection area and in the drainage blanket would be pumped to the North Quarry for settling prior to discharge pursuant to the facility's NPDES permit. This proposed closure plan is discussed in more detail in Exhibit 13, Appendix F, Volume III Edison Application at pp. CP-5 through CP-8.

Edison's proposed cap would prevent access by people and animals to the waste and would minimize erosion. It would also reduce, but not eliminate, percolation of water into the landfill. The costs for this compliance option are as follows:

Capital Costs

Cover	$3,700,000
Fence, Erosion Control	$ 300,000
Regrade waste	$ 700,000
Subtotal	$4,700,000

Annual Operation and Maintenance Costs Through 2015

Existing Water Handling System	$ 142,000
Groundwater Monitoring	$ 50,000
NPDES	$ 5,000
Subtotal	$ 197,000

Annual Post Closure Care Costs

Inspection	$ 12,000
Modified Water Handling System	$ 10,000
Groundwater Monitoring	$ 50,000
NPDES	$ 5,000
Cover	$ 5,000
Mowing and Seeding	$ 3,000
Subtotal	$ 85,000

TOTAL PRESENT VALUE COSTS $5,690,000

See Exhibit 12, option 3A.

By comparison to the generally applicable requirements, Edison's proposed cover standards would necessitate significantly lower capital and operating expenditures and, as discussed below, would also provide environmental benefits comparable to those under the generally applicable rules.

4. Edison's Proposed Final Cover Standards Will Provide Environmental Benefits That Are Comparable to Those Obtained under the Generally Applicable Final Cover Standards.

The Board's generally applicable cover system has little or no favorable environmental impact when compared to a "wet" cover for wet closure or a two-foot thick compacted clay layer for "dry" closure. The Board's generally applicable cover standards were promulgated to meet the following environmental objectives:

- minimization of water percolation and infiltration into the waste;

- control of water run-off from the cover;
- maximization of evapotranspiration;
- controlling landfill gas; and
- prevention of cover erosion and minimization of maintenance.

Most of these environmental concerns do not apply to Lincoln Quarry. For those concerns that do apply, however, Edison's proposed modified cover systems would achieve environmental benefits comparable to the generally applicable system at a lower cost, as discussed below.

a. <u>Environmental concerns applicable to wet closure</u>

(1) <u>Minimization of Water Percolation and Infiltration into the Waste</u>.

If Edison dewatered Lincoln Quarry and installed a final cover, direct precipitation no longer would reach the bottom ash and slag. However, a portion of the precipitation falling on the cover would percolate (infiltrate) through the cover and reach the ash. The amount of percolation through the cover would depend upon the cover design. For a final cover installed in compliance with the Board's standard (separate low-permeability layer, 3 foot protective layer, vegetated), about 1,820 gpd of water would percolate through the cover and reach the waste, based upon an assumed infiltration rate of 2%. On a daily basis, this amounts to about 0.16 fluid ounces of water per square foot of cover. Because the cover system does not affect the rate of groundwater inflow [600,000 gpd], percolation through the cover in this case would amount to about 0.3% of the total estimated groundwater inflow rate. Thus, by installing a cover that fully complies with the Board's standards, Edison would reduce the volume of water reaching the waste by 8,298 gpd or 1.4% of the water reaching the waste on a daily basis. The environmental benefit to be gained from this incremental reduction is minimal.

Greater percolation rates would exist for other closure scenarios. As these percolation rates increase, the benefit to be gained from covering Lincoln Quarry decreases by comparison to Edison's proposed wet closure option. For instance, under Edison's proposed dry closure scenario (2 feet of compacted clay, 4 inches topsoil, vegetated) about 13,660 gpd of water would percolate through the cover, based upon 15% infiltration rate. This amounts to only 2.3% of the total estimated daily groundwater inflow rate [600,000 gpd], or about 1.18 fluid ounces per square foot per day that reaches the bottom ash and slag waste due to precipitation. Once again, the environmental benefit to be gained by reducing the volume of precipitation reaching the waste is minimal.

Although small by comparison to groundwater inflow, the volume of precipitation reaching the waste under Edison's proposed cover system is slightly larger than the volume that would reach the waste if no cover were installed. This apparently anomalous situation exists because the proposed cover system reduces the beneficial effects of evaporation at the Quarry. Evaporation rates from the open surface of the Main Quarry are substantial, significantly reducing the volume of precipitation reaching the waste. By comparison, the evaporation rate decreases markedly for the soil cover material. Thus, once a cover system is installed, a significant volume of water will percolate through that cover system and will not be offset by evaporation from the Quarry. For any cover system with an infiltration rate greater than 11%, the amount of precipitation reaching the waste in the Main Quarry will actually increase after the cover system is installed, thereby eliminating any environmental benefit to be gained from cover installation.[32]

(2) Control of Water Run-Off from the Cover.

Under Edison's wet closure proposal, the Quarry itself would function as the primary run-off control. At closure, sluicing operations for ash will have ceased and the total amount of water to be managed will have decreased considerably, consisting primarily of groundwater inflow, relatively nominal amounts of precipitation, and any run-off that might collect. This water, including the run-off, would be pumped to the North Quarry for settling prior to NPDES discharge.

(3) Maximization of Evapotranspiration.

This concern does not apply to wet closure at Lincoln Quarry.

(4) Control of Landfill Gas.

As a monofill, Lincoln Quarry contains only non-putrescible industrial wastes that do not generate landfill gas. Thus, no cover system will have any effect on this factor.

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[32] For general comparison, about 45,530 gpd of precipitation would percolate to the bottom ash and slag if Edison dewatered the Main Quarry but did not install a final cover (bottom ash and slag exposed at the surface). A 50% infiltration rate is assumed in this case. Even this represents only about 7.5% of the total estimated groundwater inflow rate and, on a daily basis, only about 3.93 fluid ounces per square foot per day.

(5) Prevention of Cover Erosion and Minimization of Maintenance.

The "prevention of cover erosion" factor obviously does not apply in the context of Edison's proposed wet closure approach. The wet closure approach does, however, minimize maintenance in connection with closure since cover maintenance is not required.

b. Environmental Concerns Applicable to Dry Closure.

It is possible, although highly unlikely, that at the time of closure the ash surface in Lincoln Quarry will be above the adjacent groundwater table. Under this scenario, Edison proposes a "dry" closure alternative which includes installation of a cover to address the Board's cover objectives. Edison proposes a final cover consisting of two feet of compacted clay and four inches of vegetated topsoil. As discussed below, such a cover adequately achieves the Board's final cover objectives at this Site.

(1) Minimization of Water Percolation and Infiltration into the Waste.

Edison's proposed dry closure cover would have minimal adverse environmental effects for the same reasons that wet closure at this site would result in minimal effects. As noted above, with no cover at all, net precipitation less evaporation falling on the Quarry accounts for only 1.7% of the water entering the Quarry -- groundwater accounts for the remaining 98.3%. With a cover meeting the generally applicable requirements, precipitation percolating through the cover would account for 0.3% of the water balance, with groundwater accounting for the remaining 99.7%. Because placing a cover on the Quarry limits effects of evaporation, precipitation percolating through Edison's proposed dry closure cover would account for 2.3% of the water balance at the Site, with groundwater accounting for the remaining 97.7%.[33]

As these estimates show, no cover system will significantly reduce the total amount of water that reaches the ash and contributes to leachate generation. Therefore, the incremental environmental effect on downgradient groundwater quality due to any of these options would be negligible and probably could not be measured by current analytical techniques. This incremental increase is suggested to be nominal compared to the cost associated with the full cover system.

These estimates for reduced leachate generation also assume that the integrity of the cover can be maintained. If the groundwater level in Lincoln Quarry rises, putting uplift pressure on the cap, then partial or total cap failure could result. Under this scenario, the volume of precipitation reaching the waste would approximate the volume in an uncovered landfill, offering no net reduction in the amount of leachate that is generated.

(2) Control of Water Run-Off from the Cover.

Preventing erosion of and controlling runoff from the cap are addressed

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[33] About 2,000 gpd of precipitation would percolate through the generally applicable cover based on the annual precipitation rate of 36 inches and a small assumed total infiltration rate of 2 percent. In contrast, total infiltration through Edison's proposed dry cover would be 14,000 gpd, assuming a 15 percent infiltration rate. Thus, the difference between the generally applicable cover and Edison's proposed dry cover will be 12,000 gpd (from 14,000 gpd to 2,000 gpd). This difference represents only about 2 percent of the total groundwater inflow and about 2 fluid ounces per day per square foot of pond area.

by the Board's cover system using a separate, three foot thick protective and vegetative layer placed over the low-permeability layer. The primary purposes of the three foot thick protective and vegetative layer are to minimize infiltration and to protect the low-permeability layer so that it continues to operate properly. As described above in the section on wet closure, minimizing infiltration at the Site is unnecessary due to the small contribution of precipitation to the total water balance of the Quarry and, therefore, the minimal environmental benefits that would result from reduction of infiltration. Therefore, protection of a low permeability layer is not a necessary function of Edison's proposed dry closure cap.

Edison's proposed cap, then, can be evaluated in terms of its other primary purpose, preventing human access/exposure to the waste through direct contact, contact with run-off, and contact with wind-blown waste. The most important factors in achieving these purposes are preventing erosion and controlling runoff. These objectives can be achieved through proper grading to direct runoff safely from the cover, installing a well-developed vegetative layer, and protecting against physical degradation of the cover by factors such as differential settlement and frost penetration.

Proper grading and a viable vegetative layer are integral parts of, and would be equally addressed by, both the Board's and Edison's proposed "dry" cover systems. The prairie grasses previously planted on the West Filled Area demonstrate further that a highly effective vegetative layer can readily be developed at the Site. In fact, scrub vegetation growing on exposed ash locally in the Quarry shows that the ash can support minimal vegetation.

Differential settlement and consequent impacts on the cover are not a significant issue at Lincoln Quarry because the ash waste, particularly when deposited by sluicing, is a compacted fill which minimizes potential for differential settlement. This is demonstrated by the previously filled portion of the Quarry which exhibits no sign of significant settlement after a period of years. Adverse effects of frost penetration also are minimal because, as discussed above, it is unnecessary to protect the integrity of the low-permeability layer at the Site.

(3) Maximizing Evapotranspiration.

Maximizing evapotranspiration serves only to achieve further incremental reductions in the amount of water infiltrating the waste. Hydrogeological conditions at the Site minimize the significance of this concern and render Edison's proposed cover and the Board's cover comparable on this basis.

(4) Control of Landfill Gases.

As noted above, this requirement is not applicable to this Site due to the nature of the waste

(5) Prevention of Cover Erosion and Minimization of Maintenance..

Minimizing maintenance is also an objective of the final cover system. Because of the grading and vegetation, the stability of the bottom ash materials, and the nominal adverse impact of accepting some infiltration through the cover, maintenance requirements provided by Edison's proposal should be at least equivalent to the generally applicable requirements, and possibly less. It is noted that the West Filled Area, which has been closed under Edison's proposed "dry" cover system and has been planted in prairie grass, has not required significant maintenance over a period of years.

Maintenance requirements presume that the integrity of the cover can be maintained in light of the large volume of groundwater inflow into the Quarry. If the water level in Lincoln Quarry rises, putting uplift pressure on the cap, then partial or total cap failure could result. Under this scenario, the amount of maintenance necessary to maintain either the Board's required cap or the dry closure option proposed by Edison would be significant.

5. Summary.

Edison believes that both of its proposed closure approaches adequately address the factors that persuaded the Board to adopt the generally applicable closure standards. Moreover, as noted above, the environmental differences between the generally applicable cover system and Edison's wet or dry cover proposals are insignificant when the impact on the ultimate environmental receptors is considered. Most of the water that leaves Lincoln Quarry is discharged into the Des Plaines River pursuant to an NPDES permit. Even at maximum concentrations of inorganic constituents found in the leachate, the difference in leachate generation rates between Edison's dry closure proposal and the generally applicable cover requirements would be undetectable in the flow of the Des Plaines River. Thus, the environmental impact of Edison's proposed cover system for surface waters is negligible. Edison's cover proposals also are comparable to the generally applicable proposal in preventing current and future human exposure to the waste. In light of the excessive costs that would be incurred to implement the generally applicable regulations at Lincoln Quarry, Edison respectfully requests that the Board adopt its proposed adjusted standard for closure.

J. STANDARDS LISTED ON ATTACHMENT A

In addition to the specific standards discussed above, numerous of the Board's generally applicable landfill standards clearly do not apply to the type of operations conducted at the Lincoln Quarry Site. Citations for these standards are listed on Attachment A, along with a description of the regulatory requirement and of the reason that the standard is inapplicable. Edison hereby requests that the Board confirm that these standards do not apply to Lincoln Quarry and finds that Edison's current management practices adequately satisfy the purposes behind these requirements.

III. CONCLUSION

As is shown above, the Lincoln Quarry cannot comply with certain of the Board's landfill requirements, and can achieve compliance with certain other requirements only at a cost that outweighs any perceived environmental benefits gained from compliance. Indeed, it is questionable whether compliance would yield any environmental benefits at all. For these reasons, Edison has petitioned the Board for the issuance of adjusted standards to provide relief from those requirements in the landfill regulations that were never intended to apply to facilities like Lincoln Quarry and for which compliance is technically and economically impracticable.

WHEREFORE, Edison respectfully requests that the Board issue the adjusted standards requested herein.

By: Marian E. Whiteman
One of the Attorneys for
Commonwealth Edison Company

Dated: April 1, 1996

Alan P. Bielawski
Marian E. Whiteman
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ATTACHMENT A - ADDITIONAL STANDARDS TO BE ADJUSTED

Standard to be Adjusted	Summary of Standard	Reason for Adjustment
811.105	Compaction of Waste	Wet operations necessarily deposit waste at the top of the waste pile; waste compacts automatically through settling.
811.106	Daily Cover	Wet operations prevent blowing debris, minimize access to waste by vectors, minimize the threat of fires, and minimize odors (if any).
811.107(a)	Phasing of Operations	Settling of waste within the Quarry is an integral element of the operations; waste is deposited in the Main Quarry as a whole through sluicing operations and is dispersed by additional waste placement.
811.107(b)	Working face	Lincoln Quarry does not have a "working" face like a typical landfill.
811.107(i)	Vector Control	Ash deposited in Lincoln Quarry does not attract vectors and, therefore, vector control measures are unnecessary.
811.310, 811.311, 811.312	Landfill Gas Monitoring, Landfill Gas Management System	Lincoln Quarry does not generate landfill gas.
811.313	Intermediate Cover	"Wet" operations obviate the need for cover over the coal combustion wastes.
811.321	Waste Placement	Waste placement in the Quarry through "wet" operations renders these requirements inapplicable.
811.322	Final Slopes and Stabilization	Lincoln Quarry does not contain any final slopes requiring stabilization.

CERTIFICATE OF SERVICE

I, Marian E. Whiteman, certify that on April 1, 1996 I served the attached Petition of Commonwealth Edison Company for Adjusted Standard From: 35 Ill. Admin. Code 811.814, Exhibits in support of the Petition, Request for Waiver of the Requirement That Commonwealth Edison File Ten Copies of Exhibit 13 In Connection with its Adjusted Standard Petition, and the Notice of Appearance of Counsel on the following by hand delivery:

Kevin Desharnais
Hearing Officer
Illinois Pollution Control Board
James R. Thompson Center
Suite 11-500
100 West Randolph Street
Chicago, Illinois 60601

and on the following by regular mail:

Mary A. Gade
Director
Illinois Environmental Protection Agency
2200 Churchill Road
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Judith Dyer
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John Moore
Director
Energy and Natural Resources
Department
325 W. Adams
Springfield, Illinois 62704-1892

Marian E. Whiteman

Marian E. Whiteman

THIS FILING SUBMITTED ON RECYCLED PAPER

EXHIBIT 6

BEFORE THE POLLUTION CONTROL BOARD
OF THE STATE OF ILLINOIS

IN THE MATTER OF: Petition of Commonwealth Edison Company for Adjusted Standard from 35 Ill. Adm. Code 811, 814	AS 96-9 (Adjusted Standard)

NOTICE

Dorothy Gunn, Clerk Pollution Control Board James R. Thompson Center 100 W. Randolph, Ste 11-500 Chicago, Illinois 60601	Alan P. Bielawski Marian E. Whiteman Sidley & Austin One First National Plaza Chicago, Illinois 60603

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Pollution Control Board the ILLINOIS ENVIRONMENTAL PROTECTION AGENCY'S RESPONSE TO PETITION FOR ADJUSTED STANDARD of the Illinois Environmental Protection Agency, a copy of which is herewith served upon you.

ENVIRONMENTAL PROTECTION AGENCY
OF THE STATE OF ILLINOIS

By: Judith S. Dyer
Judith S. Dyer
Assistant Counsel
Division of Legal Counsel

DATE: May 1, 1996

Illinois Environmental
Protection Agency
2200 Churchill Road
P.O. Box 19276
Springfield, IL 62794-9276

THIS FILING IS SUBMITTED ON RECYCLED PAPER

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
Petition of Commonwealth Edison Company	)	AS 96-9
for Adjusted Standard from 35 Ill. Adm.	)	(Adjusted Standard)
Code 811, 814	)	
	)	

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY'S RESPONSE TO PETITION FOR ADJUSTED STANDARD

NOW COMES the Respondent, the Illinois Environmental Protection Agency ("Agency"), by one of its attorneys, Judith S. Dyer, and in response to the Petition for an Adjusted Standard of Commonwealth Edison Company ("Edison") states as follows:

1. This response is filed pursuant to Section 106.714 of the procedural rules of the Illinois Pollution Control Board ("Board"), 35 Ill. Adm. Code 106.714. As required in Section 106.714, the Agency addresses herein each issue raised under subsections (a) through (j) of Section 106.705, 35 Ill. Adm. Code 106.705.

2. Edison filed its Petition for an Adjusted Standard with the Board on April 1, 1996.

3. In its petition, Edison requests that the Board adjust standards set forth at 35 Ill. Adm. Code 814.302(b)(1), 811.319(a)(2), 811.319(a)(3), 811.318(b)(3), 811.318(b)(5), 811.320(c), and 811.314 and in provisions listed in Appendix A to the petition. These standards are applicable to Edison pursuant to 35 Ill. Adm. Code 814.302.

4. **35 Ill. Adm. Code 106.705(a)**

The Petition for an Adjusted Standard contains a statement describing the standards from which adjustment is sought. This statement can be found on page 10 of the Petition.

5. **35 Ill. Adm. Code Section 106.705(b)**

The Petition includes a correct statement that the standards from which adjustment is sought were not promulgated to implement federal or federally delegated regulatory programs as applied to the site in question. This statement can be found on page 10 of the Petition.

6. **35 Ill. Adm. Code Section 106.705(c)**

Edison correctly indicates, on page 9 of the Petition, that the standards from which adjustment is sought do not specify a level of justification or other requirements to be followed in obtaining an adjusted standard.

7. **35 Ill. Adm. Code Section 106.705(d)**

In Part D of the Petition, Edison provides a detailed description of all activities relevant to its request for relief. Also, Edison has filed as Exhibit 13 its application for significant modification submitted to the Agency, containing additional information regarding the site.

8. **35 Ill. Adm. Code Section 106.705(e)**

Edison describes in detail the efforts and costs that compliance with the standards from which adjustment is sought would necessitate. The discussion of these efforts and costs can be found at pages 51-62 (leachate management and collection system), 67-68 (constituent monitoring), 76-77 (monitoring well locations), 83-85 (zone of attenuation), 94-98 (final cover), and 110 and Appendix A (technical infeasibility of complying with standards listed in Appendix A). The Agency agrees with Edison's assertion that compliance with the standards from which adjustment is sought would be economically unreasonable and, with respect to some of the standards, technically infeasible.

9. **35 Ill. Adm. Code Section 106.705(f)**

The proposed adjusted standards are presented on pages 11-16 of the Petition. The efforts and costs associated with compliance with the proposed adjusted standards are discussed in detail on pages 62-63 (leachate collection and management system), 68-69 (constituent monitoring), 78-80 (monitoring well locations), 85-86 (zone of attenuation), 98-101 (final cover), and 110 (standards listed in Appendix A). The Agency has no basis for challenging Edison's cost analyses.

10. **35 Ill. Adm. Code Section 106.705(g)**

Edison addresses the impact on the environment on pages 63-63 (leachate collection and management system), 69-71 (constituent monitoring), 78-80 (monitoring well locations), 86-88 (zone of attenuation),101-109 (final cover), and 110 (standards listed in Appendix A). The Agency agrees that implementation of the proposed adjusted standards at the site in question would not have an adverse impact on the environment.

11. **35 Ill. Adm. Code Section 106.705(h)**

Edison provides the requisite statement regarding justification on pages 8-9 of the Petition. The level of justification necessary, set forth at 415 ILCS 5/28.1(c), is stated on page 8 of the Petition.

12. **35 Ill. Adm. Code Section 106.705(i)**

Edison addresses the consistency of the Petition with federal law on pages 10-11. The Agency agrees that the Petition may be granted consistent with federal law.

13. **35 Ill. Adm. Code Section 106.705(j)**

On page 2 of the Petition, Edison waives a hearing. The Agency agrees that no hearing is necessary in this proceeding.

14. To expedite this proceeding, Edison provided the Agency the opportunity to comment on draft versions of the Petition, and revised the Petition to address the Agency's stated concerns, prior to submittal of the Petition to the Board.

15. The Agency agrees with Edison that the factors relating to Edison are substantially and significantly different from the factors relied on by the Board in adopting the regulation of general applicability, that the existence of those factors warrants an adjusted standard, that the requested standards will not result in environmental or health effects substantially and significantly more adverse than the effects considered by the Board in adopting the rule of

general applicability, and that the adjusted standard is consistent with applicable federal law.

WHEREFORE, for the above-stated reasons, the Agency recommends that the Board grant in full the instant petition seeking adjusted standards.

Respectfully submitted,

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

By: ________________________
Judith S. Dyer
Assistant Counsel
Division of Legal Counsel

2200 Churchill Road
P.O. Box 19276
Springfield, Illinois 62794-9276
(217) 782-5544

STATE OF ILLINOIS)
)
COUNTY OF SANGAMON)

PROOF OF SERVICE

I, the undersigned, on oath state that I have served the attached **ILLINOIS ENVIRONMENTAL PROTECTION AGENCY'S RESPONSE TO PETITION FOR ADJUSTED STANDARD** upon the person to whom it is directed, by placing a copy in an envelope addressed to:

Dorothy Gunn, Clerk
Pollution Control Board
James R. Thompson Center
100 W. Randolph, Ste 11-500
Chicago, Illinois 60601

Alan P. Bielawski
Marian E. Whiteman
Sidley & Austin
One First National Plaza
Chicago, Illinois 60603

and mailing it from Springfield, Illinois on May 1, 1996 with sufficient postage affixed.

Brenda Boehner

SUBSCRIBED AND SWORN TO BEFORE ME
this 1st day of May

Cynthia L. Wolfe
Notary Public

OFFICIAL SEAL
CYNTHIA L. WOLFE
NOTARY PUBLIC STATE OF ILLINOIS
MY COMMISSION EXPIRES 6-2-99

THIS FILING IS SUBMITTED ON RECYCLED PAPER

EXHIBIT 7

ORIGINAL

RECEIVED
CLERK'S OFFICE
FEB 11 2003
STATE OF ILLINOIS
Pollution Control Board

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:)
)
PETITION OF METROPOLITAN WATER)
RECLAMATION DISTRICT OF GREATER)
CHICAGO FOR AN ADJUSTED STANDARD)
FROM 35 Ill. Adm. Code 811, 812 and 817, and) AS 03-02
MODIFICATION OF AS 95-4) (Adjusted Standard-Land)
(SLUDGE APPLICATION))
)

NOTICE OF FILING

TO: Division of Legal Counsel
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276

Office of Legal Services
Illinois Department of
Natural Resources
524 S. Second Street
Springfield, IL. 62701-1787

PLEASE TAKE NOTICE that on February 11, **2003**, we filed the attached **Petition for an Adjusted Standard, Request to Incorporate Documents by Reference** and **Appearance** with the Clerk of the Pollution Control Board, a copy of which is herewith served upon you.

Metropolitan Water Reclamation
District of Greater Chicago,

By: ______________________
Michael G. Rosenberg, its Attorney

Michael G. Rosenberg/Ronald M. Hill
Metropolitan Water Reclamation
District of Greater Chicago
100 East Erie Street
Chicago, IL 60611
(312) 751-6583

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
PETITION OF METROPOLITAN WATER	)	
RECLAMATION DISTRICT OF GREATER	)	
CHICAGO FOR AN ADJUSTED STANDARD	)	
FROM 35 Ill. Adm. Code 811, 812 and 817, and	)	AS 03-02
MODIFICATION OF AS 95-4	)	(Adjusted Standard-Land)
(SLUDGE APPLICATION)	)	
	)	

NOTICE OF FILING

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Metropolitan Water Reclamation
District of Greater Chicago,

By: ______________________
Michael G. Rosenberg, its Attorney

Michael G. Rosenberg/Ronald M. Hill
Metropolitan Water Reclamation
District of Greater Chicago
100 East Erie Street
Chicago, IL 60611
(312) 751-6583

RECEIVED
CLERK'S OFFICE
FEB 11 2003
STATE OF ILLINOIS
Pollution Control Board

ORIGINAL

STATE OF ILLINOIS)
) **SS.**
COUNTY OF COOK)

CERTIFICATE OF SERVICE

I, Judith A. Pappalardo, being duly sworn on oath, certify that I caused a copy of the attached **Petition for an Adjusted Standard, Request to Incorporate Documents by Reference, Notice of Filing/Certificate of Service** and **Appearance** to be sent via first class U.S. Mail to the below named at their addresses as shown, with proper postage prepaid, from 100 E. Erie Street, Chicago, Illinois, at or near the hour of 4:00 p.m., this 11th day of February, 2003.

Division of Legal Counsel
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276

Office of Legal Services
Illinois Department of
Natural Resources
524 S. Second Street
Springfield, IL. 62701-1787

Judith A. Pappalardo

SUBSCRIBED and SWORN to before me this 11th **day of February, 2003.**

Rosalie Bottari
Notary Public

"OFFICIAL SEAL"
Rosalie Bottari
Notary Public, State of Illinois
My Commission Exp. 04/10/2006

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
PETITION OF METROPOLITAN WATER	)	
RECLAMATION DISTRICT OF GREATER	)	
CHICAGO FOR AN ADJUSTED STANDARD	)	
FROM 35 Ill. Adm. Code 811, 812 and 817, and	)	AS 03-02
MODIFICATION OF AS 95-4	)	(Adjusted Standard-Land)
(SLUDGE APPLICATION)	)	
	)	

APPEARANCE

I hereby file my appearance in this proceeding on behalf of the Metropolitan Water Reclamation District of Greater Chicago.

Metropolitan Water Reclamation District of Greater Chicago

Michael G. Rosenberg, Attorney

DATED: February 11, 2003

Metropolitan Water Reclamation
District of Greater Chicago
Michael G. Rosenberg
Ronald M. Hill
100 East Erie Street
Chicago, Illinois 60611
(312)751-6583

THIS FILING IS SUBMITTED ON RECYCLED PAPER

ORIGINAL

RECEIVED
CLERK'S OFFICE
FEB 11 2003
STATE OF ILLINOIS
Pollution Control Board

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:)
)
PETITION OF METROPOLITAN WATER)
RECLAMATION DISTRICT OF GREATER)
CHICAGO FOR AN ADJUSTED STANDARD)
FROM 35 Ill. Adm. Code 811, 812 and 817, and) AS 03-02
MODIFICATION OF AS 95-4) (Adjusted Standard - Land)
(SLUDGE APPLICATION))
)
)
)

PETITION FOR AN ADJUSTED STANDARD

DATED: February 11, 2003

Metropolitan Water Reclamation
District of Greater Chicago
Michael G. Rosenberg
Ronald M. Hill
100 East Erie Street
Chicago, Illinois 60611
(312)751-6583

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	
PETITION OF METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO FOR AN ADJUSTED STANDARD FROM 35 Ill. Adm. Code 811, 812 and 817, and MODIFICATION OF AS 95-4 (SLUDGE APPLICATION)	)	AS 03-____ (Adjusted Standard - Land)
	)	

PETITION FOR AN ADJUSTED STANDARD

Petitioner, Metropolitan Water Reclamation District of Greater Chicago ("District"), by its Attorney, Michael G. Rosenberg, petitions the Illinois Pollution Control Board ("Board") under Section 28.1 of the Illinois Environmental Protection Act, 415 ILCS 5/28.1, to grant the District an adjusted standard from 35 Ill. Adm. Code 811.204, 811.314(c)(3), 812.313(d), 817.303 and 817.410(c)(2) and (3), which require use of soil as a final cover at landfills in Illinois, as well as from the final order in AS 95-4. In support hereof, the District states as follows:

I. INTRODUCTION

This petition seeks several modifications to the order of the Board entered on August 24, 1995, in the matter of *Petition of the Metropolitan Water Reclamation District of Greater Chicago for Adjusted Standard From 35 Ill. Adm. Code 811, 812, and 817 (Sludge Application),* docket number AS 95-4. (A copy of the Opinion and Order of the Board entered August 24, 1995, is marked Exhibit "A" and attached hereto.) In AS 95-4, the Board granted the District's petition for an adjusted standard to the Board's rules of general applicability found at 35 Ill.

Adm. Code 811.204, 811.314(c)(3), 812.313(d), 817.303 and 817.410(c)(2) and (3) for use of soil as a final cover at landfills in Illinois. Basically, the order authorized the use of the District's air-dried sludge material at non-hazardous waste landfills in lieu of soil material for the top protective layer for final cover to support vegetation.

As will be discussed in greater detail in this petition, the District is seeking to modify the temperature and detention time requirements in AS 95-4, which will make the proposed modifications entirely consistent with the Class B pathogen requirements of the Part 503 sludge regulations. In addition, the District is requesting that the order distinguish between biosolids and sludge.

II. PROCEDURAL BACKGROUND

On March 31, 1995, the District submitted a *Petition of the Metropolitan Water Reclamation District of Greater Chicago for Adjusted Standard From 35 Ill. Adm. Code 811, 812, and 817 (Sludge Application),* docket number AS 95-4, seeking an adjusted standard to the Board's rules of general applicability found at 35 Ill. Adm. Code 811.204, 811.314(c)(3), 812.313(d), 817.303 and 817.410(c)(2) and (3). The District sought an adjusted standard in order that the District's air-dried sludge material could be used at non-hazardous waste landfills in lieu of soil material for the top protective layer for final cover to support vegetation. On August 24, 1995, the Board issued an opinion and order granting the District the relief sought in its petition.

The relief granted by the Board in AS 95-4 was conditioned upon the sludge being processed in accordance with certain conditions enumerated in the order. Those conditions included: "Anaerobic digestion at 95° ± 1° F for a minimum of 15 days or longer, as necessary to ensure that the District's air-dried sludge product will meet the USEPA's Part 503 pathogen requirements for a Class B sludge; Storage in lagoons for a minimum of 1 and 1/2 years after the final addition of sludge; and Air-drying for a minimum of 4 weeks, or as necessary to achieve a solids content of 60 percent."

On March 13, 1998, the District filed a *Petition of the Metropolitan Water Reclamation District of Greater Chicago for Adjusted Standard From 35 Ill. Adm. Code 811, 812, and 817 (Sludge Application),* docket number AS 98-5, basically seeking a clarification of the Board's order in AS 95-4. On May 7, 1998, the Board issued an order dismissing AS 98-5. On June 2, 1998, the District filed for a motion of modification of the Board's May 7, 1998 order. The Board denied the District's request of a motion for modification on August 6, 1998, stating that "the Board's Order of May 7, 1998, clearly states the Board's position regarding the existing adjusted standard and further clarification of the Board's May 7, 1998 Order is not necessary."

A. <u>Facts Necessitating This Petition</u>

In 2001, the District reviewed AS 95-4 while in the process of preparing Standard Operating Procedures ("SOPs") for the operation of the District's sludge processing trains ("SPTs") for the National Biosolids Partnership (an alliance of the Association of Metropolitan Sewerage Agencies, Water Environment Federation, United States Environmental Protection Agency, and other stakeholders to advance environmentally sound and accepted sewage sludge management practices). During this review, it was realized that the anaerobic digestion temperature requirements of 95° ± 1° F in the Board's AS 95-4 opinion and order may not always be met at the District water reclamation plants ("WRPs") that produce sewage sludge used under AS 95-4.

The original intent of AS 95-4 was to ensure that the District's air-dried sludge product would meet the Class B pathogen requirements in the United States Environmental Protection

Agency (USEPA) Part 503 Sewage Sludge Regulations. Although the temperature in the anaerobic digesters may be lowered temporarily during digester feedings and briefly fluctuate below the minimum of the 95° ± 1°F criterion in AS 95-4, the District's digesters always achieve a monthly mean temperature of 95° F or above and meet the Part 503 Sludge Regulations time and temperature requirements for Class B sewage sludge.

In October of 1999, the USEPA issued a revised guidance document entitled *Environmental Regulations and Technology, Control of Pathogens and Vector Attraction in Sewage Sludge, (Including Domestic Septage) Under 40 CFR Part 503.* (A copy of the relevant provisions from this guidance document is marked Exhibit "B" and attached hereto.) The guidance document addresses the relevant time and temperature requirements necessary in the treatment of sludge to Class B standards when employing anaerobic digestion. The guidance document states in relevant part as follows:

> "Values for the mean cell residence time and temperature shall be between 15 days at 35°C to 55°C (95°F to 131°F) and 60 days at 20°C (68°F). Straight line interpolation to calculate mean cell residence time is allowable when the temperature falls between 35°C and 20°C."

This was the intent of AS 95-4, but it is not explicitly stated as such in AS 95-4.

The inconsistency in the time/temperature provisions of paragraph 3(a) in AS 95-4 and the Class B pathogens requirements, Appendix B(A)(3) of the Part 503 Sewage Sludge Regulations, occurred when preparing the initial submittal to the Board. (See Attachment 14 of the AS 95-4 petition, which petition the District has sought to incorporate by reference into the instant proceeding.) This inconsistency went undetected. The inconsistency also included reporting temperatures in Fahrenheit instead of Celsius. In the 350-plus pages of the proceedings for AS 95-4, there are only two narrative sentences in the District's petition that mention time/temperature, and the contents of both were inconsistent with the District's Order as proposed and adopted by the Board. This inconsistency was never one of the contested issues, and it was never commented upon during the AS 95-4 proceedings.

At the time of the development of the District's submittal to the Board for an adjusted standard, there were some uncertainties on how sewage sludge as a final protective vegetative cover for municipal solid waste landfills ("MSWLF") would be regulated under the Part 503 Sewage Sludge Regulations. The USEPA had just promulgated two sets of regulations that were relevant to the use of sewage sludge for the top protective layer in MSWLFs.

First, the USEPA regulated the type of material which may be used at non-hazardous MSWLF facilities through its RCRA Subtitle D regulations at 40 CFR 258, *Criteria for Municipal Solid Waste Landfills*, effective October 9, 1993. (See Attachment 1 of AS 95-4). The Board in AS 95-4 did not consider these regulations as a barrier to the use of the District's sewage sludge as a final cover at landfills in Illinois.

Next, the USEPA promulgated its final Part 503 Sewage Sludge Regulations for the use and disposal of municipal sludge on February 19, 1993. Not only do the Part 503 Sewage Sludge Regulations not regulate non-hazardous waste landfills, but the USEPA in the Preamble, page 9258, specifically endorsed the use of municipal sludge as a cover material in non-hazardous waste landfills for the support and enhancement of vegetative growth. (See Attachment 2 of AS 95-4.) It was concluded that sewage sludge used as a final vegetative cover at MSWLFs is not regulated by the Part 503 Sewage Sludge Regulations. Also, the adjusted standard was compatible with the sludge regulations of 40 CFR Part 503, and conformed to the amendments in 40 CFR 257 and 403 of the Clean Water Act.

The District, at the time of preparing the submittal for the adjusted standard to the Board, was also working on obtaining approval from USEPA for certification of the SPTs as equivalent to a Process to Further Reduce Pathogens (PFRP). In 1998, a letter was sent to the Pathogen Equivalence Committee (PEC) of the USEPA. (See Exhibit "C" attached hereto.) On page 3 of this letter, the District proposed modifying the codified sludge SPT operation, previously submitted to USEPA in August 1994, as follows:

> "The operating temperatures of the anaerobic digesters were codified as 35°C ± 2°C (95° ± 3.6°F), instead of 35°C ± 1°C.
>
> This change will provide operational flexibility and recognize events such as instrument malfunction, and the fact the digesters operate at detention times in excess of conventional requirements."

This is one of the current codified operational protocols that the District used to obtain approval from the PEC that the District's SPTs are equivalent to PFRP, and produce a final sewage sludge product which meets the USEPA's "Class A" numerical criteria for pathogens under the Part 503 Sewage Sludge Regulations. The AS 95-4 does not reflect this change in the codified operational protocol for the District's STPs.

The District in a letter to Mr. John Colletti, USEPA, Region V, dated November 30, 2001 Exhibit "D", submitted a request for certification of site-specific PFRP for the low solids and high solids SPTs at the Stickney and Calumet WRPs. In a letter dated June 20, 2002, to Mr. Jack Farnan, General Superintendent Exhibit "E", the USEPA, Region V, granted a conditional site-specific certification of equivalency to a PFRP for the low and high solids SPTs at the District's Stickney and Calumet WRPs.

A recent examination of the temperatures recorded during sludge treatment in the heated anaerobic digesters indicates that the temperatures occasionally fluctuate to a small degree above and below the temperature limit in paragraph 3(a) of the Board's Order in AS 95-4. However, it should be noted that the Class B pathogen requirements are always being met, although there is a small degree of temperature fluctuation when the sludge is fed into and drawn off from the anaerobic digesters. In fact, by virtue of the further processing required under AS 95-4, the sludge that is produced by the District's SPTs meets the Class A pathogen requirements of the Part 503 Sewage Sludge Regulations.

These fluctuations are implicitly accepted by the USEPA in the Part 503 Sewage Sludge Regulations, as noted previously, and in Exhibit "B". However, the current wording of AS 95-4 does not take into account these occasional temperature fluctuations. Consequently, it is prudent to make the appropriate changes to the AS 95-4, so that the language of the Board Order in AS 95-4 will be consistent with the language of the Part 503 Sewage Sludge Regulations, and consistent with the codified operational requirements of the District's site-specific equivalency certification for a PFRP process granted by the USEPA, Region V.

The District was in the early stages of codifying its operational requirements in the SPTs to produce Class A sewage sludge at the time the Board's Order on AS 95-4 was issued on August 24, 1995. Since then, there has been a marked improvement in the processing of sludge in the District's low and high solids SPTs. The District is now consistently producing a final sewage sludge product that meets the Class A pathogen requirements of the Part 503 Sewage Sludge Regulations, as verified by extensive testing of sludge samples for pathogens, and the granting of site-specific equivalency for a PFRP by the USEPA, Region V. Class B sludge is achieved after anaerobic digestion, and Class A sludge is achieved after lagooning the anaerobically digested sludge, and subsequently air-drying it, as is required by AS 95-4.

In addition, the District is seeking one further change to AS 95-4. Specifically, the District is requesting to change the terminology throughout the Order by establishing a distinction between the words "sludge" and "biosolids." This proposed modification would use the word "sludge" when referring to the solid material produced at several stages of municipal wastewater treatment that has not been treated or processed through digestion, while "biosolids" would refer to the primarily organic semi-solid product produced by wastewater treatment processes that have been treated to meet federal and state regulations for beneficial use and recycling by land application or other methods. This distinction is now uniformly recognized by the USEPA, wastewater treatment agencies, and others throughout the industry.

In view of the foregoing considerations, the District requests that the current specifications for anaerobic digestion of sludge in AS 95-4 be modified so that they are consistent with the specifications of the USEPA's Class B pathogen requirements. The temperature and detention times indicated by the standard operating procedures of the District's SPTs are consistent with the Class B pathogen requirements of the Part 503 Sewage Sludge Regulations. The District further requests that the adjusted standard draw a distinction between sludge and biosolids as described herein.

III. <u>INFORMATIONAL REQUIREMENTS OF 35 ILL. ADM. CODE 104.406</u>

At the outset, the District wishes to note that much of the information required by the Code in support of the District's petition has already been supplied to the Board in AS 95-4. The District has filed a request pursuant to 35 Ill. Adm. Code 101.306 asking that the petition and supporting documents filed in AS 95-4 be incorporated into this proceeding. In an effort to avoid redundancy, and to keep the record in the instant proceeding more manageable, information previously supplied to the Board in the District's prior petition will not be repeated herein, but simply incorporated herein by reference to section and page number. In addition, each section will be supplemented as necessary.

A. 104.406(a): Standard from which an adjusted standard is sought.

The District is seeking to modify the adjusted standard granted in AS 95-4, which approved the use of District sludge for final cover at non-hazardous waste landfills if the sludge meets the criteria set forth in AS 95-4. There has been no change in this requirement since AS 95-4 was approved by the Board on August 24, 1995.

In AS 95-4, the Board granted the District relief from various sections of the Code addressing soil material. The sections of the Code referencing the use of soil material at non-hazardous waste landfills are: 35 Ill. Adm. Codes 811.204, 811.314(c)(3), and 812.813(d), (effective on September 18, 1990), and 817.303 and 817.410(c)(2) and (c)3 (effective on August 1, 1994). Section 811.314 was amended on November 25, 1997, but this amendment does not impact the relief sought herein.

B. 104.406(b): Whether the regulation of general applicability was promulgated to implement, in whole or in part, the requirements of the Clean Water Act, Safe Drinking Act Water, CERCLA, Clean Air Act, or state programs concerning RCRA, UIC, or NPDES.

The District incorporates herein pages 13 and 14 of its petition in AS 95-4. The adjusted standard sought by the District, although not specifically covered by federal regulations, is entirely consistent with the biosolids regulations of 40 CFR Part 503, and conforming amendments in 40 CFR Part 257, and Section 403 of the Clean Water Act.

C. 104.406(c): The level of justification or other information or requirements specified in the regulation of general applicability or a statement that there is no such specification.

The regulation of general applicability does not specify a level of justification, or other information or requirements regarding the soil material standard for which the District is requesting an adjusted standard.

D. 104.406(d): Description of Petitioner's activity that is the subject of the proposed adjusted standard.

The activities conducted by the District were described in detail in AS 95-4, Section 106.705(d), pages 14 through 23. The District incorporates by reference the information contained therein. Furthermore, in order to update the information in our prior petition, we are attaching hereto a report dated March 13, 2002, submitted by the District to Mr. Thomas L. Bramscher, USEPA, Region V. The report describes the District's activities conducted in 2001 under the Part 503 regulations, 40 CFR Part 503. (See Exhibit "F" attached hereto.)

E. 104.406(e): Efforts needed to comply with the regulation of general applicability and compliance alternatives, including costs.

No amount of District effort will result in compliance with the regulatory requirement to use soil material. The District generates air-dried biosolids as a final component of its water reclamation processes, as described in AS 95-4. Consequently, the District believes that this informational requirement is not applicable, as described in AS 95-4, Section 106.705(e), pages 23 through 26, and incorporated herein by reference.

With respect to compliance with AS 95-4, no amount of effort or expenditures wil enable the District to comply with the anaerobic digestion temperature requirements all of the time.

F. 104.406(f): A narrative description of the proposed adjusted standard and proposed language for a Board order that would impose the standard, as well as efforts necessary to achieve the proposed standard and corresponding costs.

The District is requesting that the Board allow the application of the District's air-dried biosolids product as an alternative to soil material wherever the application of soil material is required in 35 Ill. Adm. Codes 811, 812, and 817 as the final protective layer supporting vegetation at non-hazardous waste landfills. This petition relies upon the information contained in the District's AS 95-4 petition, as well as the final opinion and order adopted by the Board on August 24, 1995, to meet the requirements of the narrative description and the efforts necessary to achieve the proposed standard and corresponding costs for this section.

The District's current wastewater processing and treatment procedures would not be changed by modifying the current AS 95-4. This is because the proposed modification would correct the wording in the Order to make it consistent with current operational protocols, the site-specific certification of equivalency for a PFRP by USEPA, Region V, and the Class B pathogen requirements in the Part 503 Sewage Sludge Regulations. Consequently, there would be no substantial change in the operating and monitoring costs associated with wastewater treatment and processing to produce a final biosolids product suitable for use as a final vegetative cover at solid waste municipal landfills. The final biosolids product currently being used for final vegetative cover at landfills under AS 95-4 meets the Class B pathogen

With respect to compliance with AS 95-4, no amount of effort or expenditures will enable the District to comply with the anaerobic digestion temperature requirements all of the time.

F. 104.406(f): A narrative description of the proposed adjusted standard and proposed language for a Board order that would impose the standard, as well as efforts necessary to achieve the proposed standard and corresponding costs.

The District is requesting that the Board allow the application of the District's air-dried biosolids product as an alternative to soil material wherever the application of soil material is required in 35 Ill. Adm. Codes 811, 812, and 817 as the final protective layer supporting vegetation at non-hazardous waste landfills. This petition relies upon the information contained in the District's AS 95-4 petition, as well as the final opinion and order adopted by the Board on August 24, 1995, to meet the requirements of the narrative description and the efforts necessary to achieve the proposed standard and corresponding costs for this section.

The District's current wastewater processing and treatment procedures would not be changed by modifying the current AS 95-4. This is because the proposed modification would correct the wording in the Order to make it consistent with current operational protocols, the site-specific certification of equivalency for a PFRP by USEPA, Region V, and the Class B pathogen requirements in the Part 503 Sewage Sludge Regulations. Consequently, there would be no substantial change in the operating and monitoring costs associated with wastewater treatment and processing to produce a final biosolids product suitable for use as a final vegetative cover at solid waste municipal landfills. The final biosolids product currently being used for final vegetative cover at landfills under AS 95-4 meets the Class B pathogen requirements of the Part 503 Sewage Sludge Regulations, and the proposed modification of the wording in the Order will not alter or change the final biosolids product being produced by the District's SPTs, as described in AS 95-4. In fact, because of the further processing required under AS 95-4, the biosolids that are produced by the District's SPTs meets the Class A pathogen requirements of the Part 503 Sewage Sludge Regulations.

The AS 95-4 petition, section 106.705 (e), pages 23 through 26, describes the cost savings to the District for substitution of its sludge for soil in landfill closure. The section also describes the estimated cost savings to the landfill operator for the substitution of the District's biosolids for soil material as a final vegetative cover. The cost savings described in AS 95-4 and the benefit to the District and its taxpayers in 1995 are the same in 2003. The proposed modification of AS 95-4 will not change the previously described costs and benefits to the District, its taxpayers, and landfill operators, and it will not change the District's current operating and monitoring costs for producing a final biosolids product suitable for use as a final vegetative cover in municipal solid waste landfills.

Proposed Order. The District, in accordance with the requirement of 104.406(f), proposes the following modification to the AS 95-4 Order adopted on August 24, 1995, with the modified Order to read as follows:

PROPOSED ORDER

The Board hereby grants the District's motion to modify the adjusted standard that was adopted in the Board Order of August 24, 1995, pursuant to the authority of Section 28.1 of the Environmental Protection Act, and the Order shall now read as follows:

1. This adjusted standard applies only to the air-dried ~~sludge~~ **biosolids** product generated by the Metropolitan Water Reclamation District of Greater Chicago (District).

2. District ~~sludge~~ **biosolids** that ~~complies~~ **comply** with the conditions in paragraph 3 below ~~is~~ **are** approved as an alternative to the soil material standard at the inert waste, the putrescible (MSWLF) and chemical waste landfills, or the steel and foundry industry potentially useable and low risk waste classes of landfills regulated at 35 Ill. Adm. Codes 810-815 and 817, for application as the final protective layer, as the final cover. The sections where the soil material standard is used are 35 Ill. Adm. Codes 811.204, 811.314(c)(3), 812.813(d), 817.303 and 817.410(c)(2) and (c)(3).

3. When providing ~~sludge~~ **biosolids** for the applications enumerated in Paragraph 2, the District shall provide air-dried ~~sludge~~ **biosolids** as described in its petition for an adjusted standard **(AS 95-4)** and in its **motion for modification** and processing in accordance with the following conditions:

   a. Anaerobic digestion**: (1)** at ~~95° ± 1°F~~ **35 to 55 degrees Celsius, except when a digester temperature, lowered temporarily due to digester feedings, might occasionally and briefly fluctuate below the minimum, and (2)** for a minimum of 15 days or longer, ~~as necessary~~ **with digestion temperatures and times (i.e. "Values for the mean cell residence time and temperature shall be between 15 days at 35 to 55 degrees Celsius and 60 days at 20 degrees Celsius") managed so as** to ensure that the District's ~~air-dried sludge~~ **anaerobically digested** product **is consistent with** ~~will meet~~ the USEPA's ~~Part 503~~ pathogen **treatment** requirements for a Class B ~~sludge~~ **biosolids**; **(40 CFR Part 503, Appendix B(A)(3))**; and

   b. Storage in lagooons for a minimum of 1 and ½ years after the final addition of ~~sludge~~ **biosolids**; and

   c. Air-drying for a minimum of 4 weeks, or as necessary to achieve a solids content of 60 percent.

4. When providing ~~sludge~~ **biosolids** for the applications enumerated in Paragraph 2, the District shall limit the ~~sludge~~ **biosolids** provided to amounts that are sufficient for a final depth of three feet as compacted using normal landscaping practices.

5. The District will report to the Agency the start up, discontinuance, and quality of ~~sludge~~ **biosolids** deliveries to each facility;

6. District ~~sludge~~ **biosolids**, when used in compliance with this adjusted standard, are not a waste.

G. 104.406(g): Quantitative and qualitative description of the impact of the petitioner's activity on the environment if the petitioner were to comply with the regulation of general applicability as compared to the quantitative and qualitative impact on the environment if the petitioner were to comply only with the proposed adjusted standard.

Modification of AS 95-4 as requested herein will have the same quantitive and qualitative impact on the environment as the original adjusted standard as set forth in AS 95-4, Section 106.705(g), pages 34 through 52, which the District incorporates herein by reference.

H. 104.406(h): A statement of justification for the proposed adjusted standard.

The regulation of general applicability does not specify a level of justification required to qualify for an adjusted standard. Therefore, the District must establish that it complies with the criteria set forth in Section 28.1(c) of the Act and the corresponding section of the Board's procedural rules at 35 Ill. Adm. Code 104.426(a).

The information provided in the District's original petition, as described in AS 95-4, Section 106.705(h), pages 52 through 58, along with the exhibits to the instant petition that supplement the original petition, fully and accurately sets forth the facts supporting an adjusted standard from the regulations of general applicability. With respect to the amendment sought in the instant petition, the facts set forth herein fully describe the differences between the relief currently sought and that granted in AS 95-4, state the factors justifying an adjusted standard, and establish that the relief sought is justified.

I. 104.406(h): Consistency of proposed adjusted standard with federal law.

The District's petition is consistent with the Part 503 Sewage Sludge Regulations and its subsequent revisions by the USEPA. On February 19, 1994, the USEPA Part 503 Regulations (*Federal Register*, Volume 58, No. 32, February 19, 1993) became effective.

The USEPA made subsequent changes to the Part 503 Regulations in 1994 (*Federal Register*, Volume 59, No. 38, February 25, 1994), 1995 (*Federal Register*, Volume 60, No. 26, October 25, 1995), and 1999 (*Federal Register*, Volume 64, No. 149, August 4, 1999). Briefly, these changes were related to deleting the pollutant limit for molybdenum in biosolids applied to land but retaining the molybdenum ceiling limit; deleting the pollutant limit for chromium in biosolids applied to land; changing the pollutant concentration limit for selenium in land applied biosolids to the ceiling limit; and allowing the permitting authority greater flexibility in reducing the monitoring requirements for compliance with the Part 503 Regulations.

These regulations do not regulate the utilization of biosolids at non-hazardous waste landfills. However, they endorse the productive use of biosolids for a final protective layer at non-hazarous waste landfills, as noted in AS 95-4.

The consistency of the proposed standard with existing federal law is the same as that described in AS 95-4, Section 106.705(i), pages 58 through 60. Furthermore, the adjusted standard sought is consistent with the USEPA's Guidance Document (See exhibit "B" attached hereto), and the site-specific certification for PFRP granted by USEPA, Region V (See Exhibit "E" attached hereto.).

J. 104.406(j): A statement requesting or waiving a hearing on the Petition.

The District waives a hearing on the petition.

CONCLUSION

The District's Petition seeks several minor modifications to the adjusted standard approved by the board in AS 95-4. One change will amend the time/temperature requirements in order that they are consistent with USEPA guidance, and the site-specific certification for PFRP granted by USEPA, Region V, while the other draws on a well accepted distinction between sludge and biosolids. The modifications requested are entirely consistent with federal law and will not adversely affect the environment.

WHEREFORE, the Metropolitan Water Reclamation District of Greater Chicago respectfully requests that the Board grant the District's petition for an adjusted standard.

Respectfully submitted,

Metropolitan Water Reclamation District of Greater Chicago

Michael G. Rosenberg, its Attorney

DATED: February 6th, 2003

Michael G. Rosenberg
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Metropolitan Water Reclamation
District of Greater Chicago
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312.751.6583

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF: PETITION OF METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO FOR AN ADJUSTED STANDARD FROM 35 Ill. Adm. Code 811, 812 and 817, and MODIFICATION OF AS 95-4 (SLUDGE APPLICATION)	)	AS 03-____ (Adjusted Standard - Land)

AFFIDAVIT OF RICHARD LANYON

I, Richard Lanyon, being first duly sworn, on oath, depose and state that I am the Director of Research & Development for the Metropolitan Water Reclamation District of Greater Chicago, and that to the best of my knowledge and belief, the facts contained in the District's Petition for an Adjusted Standard are true and correct.

R. Lanyon

Richard Lanyon, Director of Research & Development, Metropolitan Water Reclamation District of Greater Chicago

Subscribed and Sworn to
before me this 6th day
of February, 2003.

Rosalie Bottari

"OFFICIAL SEAL"
Rosalie Bottari
Notary Public, State of Illinois
My Commission Exp. 04/10/2006

EXHIBIT 8

ILLINOIS POLLUTION CONTROL BOARD
July 24, 2003

IN THE MATTER OF:	)	
	)	
PETITION OF METROPOLITAN WATER	)	AS 03-2
RECLAMATION DISTRICT OF	)	(Adjusted Standard - Land)
GREATER CHICAGO FOR AN	)	
ADJUSTED STANDARD FROM 35 ILL.	)	
ADM. CODE 811, 812 AND 817 AND	)	
MODIFACITON OF AS 95-4 (SLUDGE	)	
APPLICATION)	)	

OPINION AND ORDER OF THE BOARD (by G.T. Girard):

This matter comes before the Board upon a petition for adjusted standard filed on February 11, 2003, by the petitioner, Metropolitan Water Reclamation District of Greater Chicago (District). The District requests an adjusted standard from 35 Ill. Adm. Code 811.204, 811.314(c)(3), 812.313(d), 817.303 and 817.410(c)(2) and (3), which require using soil as a final cover at Illinois landfills. The District also requests a modification of its previously granted adjusted standard in I*n re* Petition of the Metropolitan Water Reclamation District of Greater Chicago for Adjusted Standard from 35 Ill. Adm. Code 811, 812, and 817 (Sludge Application), AS 95-4 (Aug. 24, 1995).

The Board's responsibility in this matter arises from the Environmental Protection Act (Act) (415 ILCS 5/1 *et seq.* (2002)). The Board is charged to "determine, define and implement the environmental control standards applicable in the State of Illinois" (415 ILCS 5/5(b) (2002)), and to "grant . . . an adjusted standard for persons who can justify such an adjustment" (415 ILCS 5/28/1(a) (2002)). More generally, the Board's responsibility in this matter is based on the checks and balances integral to Illinois environmental governance: the Board is charged with the rulemaking and principal adjudicatory functions, and the Illinois Environmental Protection Agency (Agency) is responsible for carrying out the principal administrative duties.

The Act also provides that "the Agency shall participate in [adjusted standard] proceedings." 415 ILCS 5/28.1(d)(3) (2002). On April 4, 2003, the Agency filed a response to the petition, which the Board interprets as a recommendation. The Agency supports grant of an adjusted standard in part, and denial in part. On May 2, 2003, the District filed a reply to the Agency's recommendation and an amended petition for adjusted standard, and waived its right to a hearing.[1] The Agency did not file a recommendation regarding the amended petition.

Based upon the pleadings before it and upon review of the factors involved in the consideration of adjusted standards, for the reasons outlined below, the Board finds that the

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[1] The petition will be cited as "Pet. at __." The amended petition will be cited as "Am. Pet. at __." The Agency's recommendation will be cited as "Ag. Rec. at __." The District's reply will be cited as "District Reply at __."

District has met the requirements for an adjusted standard and grants relief from 35 Ill. Adm. Code 811.204, 811.314(c)(3), 812.313(d), 817.303 and 817.410(c)(2) and (3). The Board declines to modify the adjusted standard previously in AS 95-4, because the Board's regulations do not provide for amending the conditions in an adjusted standard eight years after granting the adjusted standard.

PROCEDURAL HISTORY

On February 11, 2003, the District filed a petition for adjusted standard from 35 Ill. Adm. Code 811.204, 811.314(c)(3), 812.313(d), 817.303 and 817.410(c)(2) and (3), so that the District's air-dried sludge material may be used at non-hazardous waste landfills instead of soil material for the top layer for final cover to support vegetation. Pet. at 1. Also on February 11, 2003, the District filed a motion to incorporate the petition and attachments filed *In re* Petition of the Metropolitan Water Reclamation District of Greater Chicago for Adjusted Standard from 35 Ill. Adm. Code 811, 812, and 817 (Sludge Application), AS 95-4 (Aug. 24, 1995). On March 6, 2003, the Board granted the motion.[2]

On April 4, 2003, the Agency filed its recommendation. The Agency recommends that the Board deny the petition to the extent the District seeks to use the term "biosolids" instead of "sludge" in the adjusted standard. Ag. Rec. at 5. The Agency is also concerned about the proposition that using sludge as final cover material will not result in environmental or health effects substantially and significantly more adverse than the effects the Board considered in adopting the rules of general applicability. Ag. Rec. at 5.

On May 2, 2003, upon receipt of the Agency's recommendation, the District filed an amended petition for an adjusted standard and a reply to the Agency's recommendation. The District made two changes in the amended petition. District Reply at 19. The District withdraws the request to use the term "biosolids" rather than "sludge." District Reply at 2; Am. Pet. at 12-13. The amended petition also corrects a typographical error in the proposed order. District Reply at 19. The District waives hearing in this matter. No hearing has been held.

ADJUSTED STANDARD PROCEDURE

In both a general rulemaking and a site-specific rulemaking, the Board is required to take the following factors into consideration: the existing physical conditions; the character of the area involved, including the character of the surrounding land uses; zoning classifications; the nature of the receiving body of water; and the technical feasibility and economic reasonableness of measuring or reducing a particular type of pollution. 415 ILCS 5/27(a) (2002). The general procedures that govern an adjusted standard proceeding are found at Section 28.1 of the Act and the Board's procedural rules at 35 Ill. Adm. Code 104. Section 28.1 also requires that the adjusted standard procedure be consistent with Section 27(a) of the Act.

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[2] The incorporated petition from AS 95-4 filed on March 31, 1995, will be cited as "AS 95-4 Pet. at __."

The District seeks an adjusted standard from rules of general applicability. In determining whether an adjusted standard should be granted from a rule of general applicability, the Board must consider, and the District has the burden to prove, the factors at Section 28.1(c) of the Act (415 ILCS 5/28.1(c) (2002)):

1) factors relating to that petitioner are substantially and significantly different from the factors relied upon by the Board in adopting the general regulation applicable to the petitioner;

2) the existence of those factors justifies an adjusted standard;

3) the requested standard will not result in environmental or health effects substantially and significantly more adverse than the effects considered by the Board in adopting the rule of general applicability; and

4) the adjusted standard is consistent with any applicable federal law. 35 Ill. Adm. Code 104.426(a) and 415 ILCS 5/28.1.

FACILITY DESCRIPTION

The District is located in Cook County, Illinois, and serves the city of Chicago and 124 suburban communities. AS 95-4 Pet. at 2. On average, the District treats about 1500 million gallons per day (MGD) of wastewater. *Id*. at 3. The wastewater is processed at seven water reclamation plants (WRPs). *Id*. at 15. Processing this wastewater generates about 200,000 dry tons of sludge in any given year. *Id*. at 3, 16. Although each WRP handles its sludge differently, the District generally processes its sludge using the following sequence of unit operations:

1. Gravity thickening

2. Centrifuge thickening

3. Anaerobic digestion

4. Centrifuge or lagoon dewatering

5. Lagoon storage

6. Air-drying (*Id.* at 16-17).

Solids processing at the District begins with the concentration of primary and secondary sludge in gravity concentration tanks. *Id.* at 17. The sludge is then anaerobically digested in heated (95° ± 1°F) high rate digesters for approximately 20 days, to reduce odor potential and destroy pathogens. *Id.* After anaerobic digestion, the liquid sludge (approximately 4% solids) is either mechanically dewatered using high speed centrifuges to approximately 25% to 30% solids or lagoon dewatered to produce 15% solids. *Id.* Both the liquid sludge and the dewatered centrifuge sludge is stored in lagoons to reduce its odor potential and further destroy pathogens.

Id. The sludge stored in lagoons is air-dried on asphalt-paved drying beds, using a mechanical agitation process to accelerate drying and further reduce pathogens. *Id.* All air-dried sludge has a high solids content of about 60%, is soil-like in appearance, low in pathogens and high in plant nutrients. *Id.*

The District ultimately utilizes the majority of its sludge as a fertilizer, soil amendment, or soil substitute. *Id*. at 17. After years of planning, the following are the options which the District has chosen for final disposition of its sludge product:

1. Sludge application to land in Fulton County, Illinois.

2. Sludge application to land at the Hanover Park water reclamation plant, Hanover Park, Illinois.

3. Landscaping at District WRPs.

4. Distribution to large-scale users for landscaping purposes (*e.g.*, Underwriters Laboratories, Worth Park District, Russell Road Interchange for the Tollway Commission.

5. Final protective layer for landfills.

6. Daily cover for landfills (*Id.* at 17-18).

REQUESTED RELIEF

The District offers the following language for the requested adjusted standard:

1. This adjusted standard applies only to the air-dried sludge product generated by the Metropolitan Water Reclamation District of Greater Chicago (District).

2. District sludge that complies with the conditions in paragraph 3 below is approved as an alternative to the soil material standard at the inert waste, the putrescible (MSWLF) and chemical waste landfills, or the steel and foundry industry potentially usable and low risk waste classes of landfills regulated at 35 Ill. Adm. Code 810-815 and 817, for application as the final protective layer, as the final cover. The sections where the soil material standard is used are 35 Ill. Adm. Code 811.204, 811.314(c)(3), 812.313(d), 817.303 and 817.410(c)(2) and (c)(3).

3. When providing sludge for the applications enumerated in paragraph 2, the District shall provide air-dried sludge as described in its petition for an adjusted standard (AS95-4) and in its motion

for modification and processing in accordance with the following conditions:

a. Anaerobic digestion:

i. at 35 to 55 degrees Celsius, except when a digester temperature, lowered temporarily due to digester feedings, might occasionally and briefly fluctuate below the minimum, and

ii. for a minimum of 15 days or longer with digestion temperatures and times (i.e., "Values for the mean cell residence time and temperature shall be between 15 days at 35 to 55 degrees Celsius and 60 days at 20 degrees Celsius") managed so as to ensure that the District's anaerobically digested product is consistent with the USEPA's pathogen treatment requirements for a Class B sludge; (40 CFR Part 503, Appendix B(A)(3)); and

b. Storage in lagoons for a minimum of one and half years after the final addition of sludge; and

c. Air-drying for a minimum of 4 weeks, or as necessary to achieve a solids content of 60 percent.

4. When providing sludge for the applications enumerated in paragraph 2, the District shall limit the sludge provided to amounts that are sufficient for a final depth of three feet as compacted using normal landscaping practices.

5. The District will report to the Agency the start up, discontinuance, and quality of sludge deliveries to each facility.

6. District sludge when used in compliance with this adjusted standard, is not a waste. Am. Pet. at 12-13.

<u>REGULATORY FRAMEWORK</u>

The District seeks and adjusted standard from 35 Ill. Adm. Code 811.204, 811.314(c)(3), 812.313(d), 817.303 and 817.410(c)(2) and (3).

Section 811.204 provides:

Final Cover

> A minimum of 0.91 meter (three feet) of soil material that will support vegetation which prevents or minimizes erosion shall be applied over all disturbed areas. Where no vegetation is required for the intended postclosure land use, the requirements of Section 811.205(b) will not apply; however, the final surface shall still be designed to prevent or minimize erosion.

Section 811.314(c)(3) provides:

> Standards for the Final Protective Layer
>
> 1) The final protective layer shall cover the entire low permeability layer.
>
> 2) The thickness of the final protective layer shall be sufficient to protect the low permeability layer from freezing and minimize root penetration of the low permeability layer, but shall not be less than 0.91 meter (3 feet).
>
> 3) The final protective layer shall consist of soil material capable of supporting vegetation.
>
> 4) The final protective layer shall be placed as soon as possible after placement of the low permeability layer to prevent desiccation, cracking, freezing or other damage to the low permeability layer.

Section 812.313(d) provides:

> The permit application shall contain documentation for the final cover system to demonstrate compliance with 35 Ill. Adm. Code 811.314, including:
>
> * * *
>
> d) A description of final protective cover, including a description of the soil and the depth necessary to maintain the proposed land use of the area;
>
> * * *

Section 817.303 provides:

> Final Cover
>
> Unless otherwise specified in a permit or other written Agency approval, a minimum of 0.46 meters (1.5 feet) of soil material that will support vegetation which prevents or minimizes erosion shall be applied over all disturbed areas.

Section 817.410(c)(2) and (3) provide:

> c) Standards for the final protective layer:
>
> * * *
>
> 2) The thickness of the final protective layer shall be sufficient to protect the low permeability layer from freezing and minimize root

penetration of the low permeability layer, but shall not be less than 0.46 meter (1.5 feet).

3) The final protective layer shall consist of soil material capable of supporting vegetation.

* * *

PREVIOUSLY GRANTED AS 95-4

On August 24, 1995, the Board granted the District an adjusted standard from 35 Ill. Adm. Code 811.204, 811. 314(c)(3), 812.313(d), 817.303, and 817.410(c)(2) and (3). *In re* Petition of the Metropolitan Water Reclamation District of Greater Chicago for Adjusted Standard from 35 Ill. Adm. Code 811, 812, and 817 (Sludge Application), AS 95-4 (Aug. 24, 1995). The relief granted in AS 95-4 was conditioned upon the sludge being processed in accordance with certain conditions set forth in the Board's order. Am. Pet. at 3. The conditions included "anaerobic digestion at 95° ± 1°F for a minimum of 15 days or longer, as necessary to ensure that the District's air-dried sludge product will meet the United States Environmental Protection Agency's Part 503 (40 C.F.R. §503) pathogen requirements for a Class B sludge; storage in lagoons for a minimum of one and a half years after the final addition of sludge; and air drying for a minimum of four weeks, or as necessary to achieve a solids content of 60%." Am. Pet. at 3.

The District requests another adjusted standard because upon reviewing AS 95-4, the District realized that the anaerobic digestion temperature requirements of 95° ± 1 °F in the Board's opinion and order in AS 95-4 may not always be met at the District's WRPs that produce sewage sludge used under AS 95-4. Am. Pet. at 3-4. Therefore, the District requests another adjusted standard that modifies the current specifications for anaerobic digestions of sludge in AS 95-4, so that the specifications are consistent with the Class B pathogen requirements of the Part 503 Sewage Sludge regulations. Am. Pet. at 8. Specifically, the District notes that the current wording of AS 95-4 does not consider the temperature fluctuations that sometimes occur, but that these types of fluctuations are implicitly accepted by the USEPA in the Part 503 Sewage Sludge regulations (40 C.F.R. §503). Am Pet. at 7.

The District would prefer if the Board would modify the adjusted standard in AS 95-4, rather than have an entirely new adjusted standard with a different docket number. District Reply. at 3. However, as the District notes, the Board's rules do not provide for a method to amend an adjusted standard eight years after the adjusted standard was granted. District Reply at 3. Therefore, rather than modify the previously granted adjusted standard in AS 95-4, the Board will grant an entirely new adjusted standard.

ARGUMENT

Substantially Different Factors

The District argues that using the District's air-dried sludge was never discussed in the landfill regulatory proceeding. AS 95-4 Pet. at 55. The District concludes that the factors relating to the use of District sludge are substantially and significantly different from those relied on in relation to the soil requirement. *Id.* at 55. The District also notes that until recently, the District was uncertain how ongoing state and federal regulatory proceedings addressing the management of landfills generally, and specifically sludge, would affect the District's sludge management program regarding landfill cover application. *Id*. at 56.

The Agency's recommendation does not address whether the factors relating to the District are substantially and significantly different from the factors relied upon by the Board in adopting the general regulation applicable to the to the District.

Justification

The District argues that no effort that the District would make will result in the compliance with the regulatory requirement to use soil material. *Id*. at 24. The District also contends that the District's petition shows that the District has a long-time investment in innovative technologies to put sludge to productive uses. *Id.* at 56. The District states that losing the beneficial productive use of air-dried sludge would be both environmentally and economically significant. *Id*. at 56.

The Agency's recommendation does not address the District's comments regarding justification, except to say that the Agency does not take issue with the District's statement that the regulations of general applicability do not specify a level of justification required to qualify for an adjusted standard. Ag. Rec. at 4.

Environmental Effect

The District states that the adjusted standard petition has shown that not only are there no substantially or significantly more adverse environmental or health effects, but in some respects, the effects under the adjusted standard are superior to those effects considered by the Board when the Board established the use of soil material for the final protective layer and intermediate cover in the landfill regulations. AS 95-4 Pet. at 57. The District contends that the sludge produced by the District is of consistent quality, can be worked like soil, contains fertilizer for encouraging speedy vegetative growth, and can protect the low permeability layer in the final cover from freezing. *Id*. at 57.

The Agency responds that that the Agency's Bureau of Water has observed elevated levels of ammonia in the storm water runoff at Land and Lakes #3 landfill, which has received sludge from the District. Ag. Rec. at 2. The Agency does not believe that elevated ammonia levels in storm water runoff is characteristic of soil material, and may reflect an environmental concern regarding the use of air-dried sludge. Ag. Rec. at 3.

The Agency also states that it is unclear whether AS 95-4 adequately addressed the quantitative and qualitative impact on ammonia from the sludge when sludge is used as final cover on landfills. Ag. Rec. at 4. The Agency believes additional monitoring and reporting should be required by the landfills using the sludge as final cover under this adjusted standard. Ag. Rec. at 4. The Agency further states that the elevated levels of ammonia may show that using sludge instead of soil as the final cover may result in environmental or health effects substantially and significantly more adverse than the effects considered by the Board in adopting the rules of general applicability. Ag. Rec. at 4.

In its reply, the District argues that the water runoff issue was thoroughly addressed to the Board's satisfaction in AS 95-4. District Reply at 5. The District argues that Land and Lakes #3 was never supplied with the District's sludge from AS 95-4. District Reply at 5. The District also contends that any unsuitable sludge shipped to Land and Lakes #3 may have been improperly accumulated or held in an area that lacked adequate drainage, runoff, and erosion controls. District Reply at 5.

The District notes that in support of its petition in AS 95-4, the District noted the following:

1) No adverse impact on surface water and groundwater quality was observed at a site in Fulton County where the District had been applying sludge for over 22 years.

2) After monitoring the groundwater quality for 10 years at 103rd and Doty Municipal Solid Waste Landfill where 225 acres were covered with a top layer of District sludge, the water quality had not changed significantly.

3) Additionally, a study by J.B. Farrell, *et al.* concluded that the addition of sludge to landfills improved the leachate quality. District Reply at 7.

The District argues that the same facts that the Board found persuasive in AS 95-4 regarding the effects of sludge as a top layer still exist today. District Reply at 8.

Additionally, the District argues that the Agency did not establish a correlation between ammonia levels at the Land and Lakes landfills and unsuitable District Sludge. District Reply at 12. The District further contends that to the District's knowledge, sewage sludge was not used as a final cover and was co-disposed because sewage sludge typically did not meet the lagoon aging and drying requirements in AS 95-4. District Reply at 14. Additionally, the District asserts that the Agency statement that the District sewage sludge used as a final vegetative cover was the source of ammonia nitrogen in landfill runoff is inaccurate. District Reply at 14.

Regarding the Agency's recommendation that additional monitoring and reporting should be required by the landfills using the sludge as final cover under this adjusted standard, the District responds that such a requirement would be overly burdensome and will present a severe impediment to the cost effective recycling of a valuable product. District Reply at 15. The District also responds that under the current regulatory structure, the Agency has a sufficient opportunity to review the use of sludge in the final protective layers at Illinois landfills before it is delivered. District Reply at 16.

Consistency with Federal Law

The District argues the petition for adjusted standard is consistent with the Part 503 Sewage Sludge Regulations and the USEPA's subsequent revisions. Am. Pet. at 14. The District further states that the consistency of the proposed standard with existing federal law is the same as that described in the petition for AS 95-4. Am. Pet. at 14. Additionally, the requested adjusted standard is consistent with the USEPA's guidance document and site-specific certification for the process to further reduce pathogens (PFRP) granted by USEPA, Region V. Am. Pet. at 14.

The Agency agrees that the consistency of the proposed standard with existing federal law is the same as that described in the petition for AS 95-4. Ag. Rec. at 4. However, the Agency is uncertain about the relevance regarding the consistency of the proposed adjusted standard with federal regulations that do no apply to solid waste landfills, and with USEPA guidance documents. Ag. Rec. at 5.

FINDINGS

Based on its review of the record in this matter, and the showings requisite for grant of an adjusted standard, the Board finds that grant of an adjusted standard in the instant case is warranted.

Substantially Different Factors

The Board first finds that the District has established that the Board did not consider the use of sludge as final cover in the adopting the regulations of general applicability. Thus, the Board finds that the factors surrounding this are substantially and significantly different from those considered by the Board in adopting the rules of general applicability.

Justification

The Board finds that the District has demonstrated the use of sludge is beneficial and cost-efficient. Therefore, the Board finds that the factors relating to the adjusted standard request justify an adjusted standard.

Environmental Effect

The only contested issue in this proceeding is whether granting the adjusted standard would result in substantially or significantly more harmful health and environmental effects. The Board finds that the District has adequately refuted the Agency's concerns that using sludge as final cover instead of soil may lead to elevated levels of ammonia. The Agency based its allegation on one landfill, Land and Lakes Landfill #3, having elevated levels of ammonia in storm water runoff and having received District sludge. The District responded that Land and Lake Landfill #3 never received District sludge from AS 95-4. Additionally, the District previously provided information in AS 95-4 that showed that water quality at both a site in

Fulton County and at 103rd and Doty Municipal Solid Waste Landfill, had not changed significantly after years of applying sludge.

Additionally, the Board declines to order additional monitoring and reporting at the sites that receive District sludge. The Agency did not refute the District's evidence that sludge has been safely used, and therefore ordering additional monitoring and reporting is not justified.

The Board is persuaded that the use of sludge will not result in substantially or significantly more harmful health and environmental effects than were considered in adopting the rule of general applicability.

Consistency with Federal Law

The Board finds, as the District suggests, that granting an adjusted standard is consistent with federal law.

SUMMARY

For the reasons detailed above, the Board grants the District an adjusted standard from 35 Ill. Adm. Code 811.204, 811.314(c)(3), 812.313(d), 817.303 and 817.410(c)(2) and (3).

This opinion constitutes the Board's findings of fact and conclusions of law.

ORDER

The Board grants an adjusted standard to the Metropolitan Water Reclamation District of Greater Chicago from 35 Ill. Adm. Code 811.204, 811.314(c)(3), 812.313(d), 817.303 and 817.410(c)(2) and (3) subject to the following conditions:

1. This adjusted standard applies only to the air-dried sludge product generated by the Metropolitan Water Reclamation District of Greater Chicago (District).

2. District sludge that complies with the conditions in paragraph 3 below is approved as an alternative to the soil material standard at the inert waste, the putrescible (MSWLF) and chemical waste landfills, or the steel and foundry industry potentially usable and low risk waste classes of landfills regulated at 35 Ill. Adm. Code 810-815 and 817, for application as the final protective layer, as the final cover. The sections where the soil material standard is used are 35 Ill. Adm. Code 811.204, 811.314(c)(3), 812.313(d), 817.303 and 817.410(c)(2) and (c)(3).

3. When providing sludge for the applications enumerated in paragraph 2, the District shall provide air-dried sludge as described in its petition for an adjusted standard in AS 03-2 and processed in accordance with the following conditions:

a. Anaerobic digestion:

j. at 35 to 55 degrees Celsius, except when a digester temperature, lowered temporarily due to digester feedings, might occasionally and briefly fluctuate below the minimum, and

ii. for a minimum of 15 days or longer with digestion temperatures and times (i.e., "Values for the mean cell residence time and temperature shall be between 15 days at 35 to 55 degrees Celsius and 60 days at 20 degrees Celsius") managed so as to ensure that the District's anaerobically digested product is consistent with the USEPA's pathogen treatment requirements for a Class B sludge; (40 C.F.R. §503, Appendix B(A)(3)); and

b. Storage in lagoons for a minimum of one and half years after the final addition of sludge; and

c. Air-drying for a minimum of 4 weeks, or as necessary to achieve a solids content of 60 percent.

4. When providing sludge for the applications enumerated in paragraph 2, the District shall limit the sludge provided to amounts that are sufficient for a final depth of three feet as compacted using normal landscaping practices.

5. The District will report to the Agency the start up, discontinuance, and quality of sludge deliveries to each facility.

6. District sludge when used in compliance with this adjusted standard, is not a waste.

IT IS SO ORDERED.

Section 41(a) of the Environmental Protection Act provides that final Board orders may be appealed directly to the Illinois Appellate Court within 35 days after the Board serves the order. 415 ILCS 5/41(a) (2002); *see also* 35 Ill. Adm. Code 101.300(d)(2), 101.906, 102.706. Illinois Supreme Court Rule 335 establishes filing requirements that apply when the Illinois Appellate Court, by statute, directly reviews administrative orders. 172 Ill. 2d R. 335. The Board's procedural rules provide that motions for the Board to reconsider or modify its final orders may be filed with the Board within 35 days after the order is received. 35 Ill. Adm. Code 101.520; *see also* 35 Ill. Adm. Code 101.902, 102.700, 102.702.

I, Dorothy M. Gunn, Clerk of the Illinois Pollution Control Board, hereby certify that the Board adopted the above opinion and order on July 24, 2003, by a vote of 6-0.

Dorothy M. Gunn, Clerk
Illinois Pollution Control Board

EXHIBIT 9

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GSI White Paper #28

"Cold Temperature and Free-Thaw Cycling Behavior of Geomembranes and Their Seams"

by

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Denver, Colorado

June 17, 2013

"Cold Temperature and Free-Thaw Cycling Behavior of Geomembranes and Their Seams"

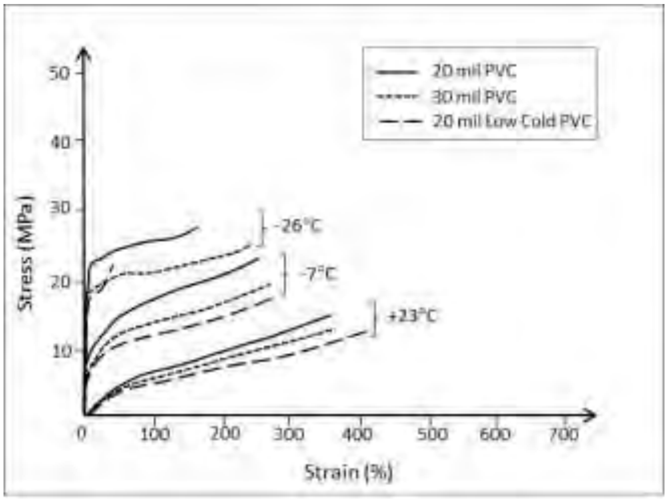
Introduction

It is common knowledge that materials in general, and polymeric materials in particular, will somewhat soften and increase in flexibility under high temperatures and will conversely somewhat harden and decrease in flexibility under cold temperatures. While there are indeed circumstances where high ambient temperatures are important, this white paper focuses entirely on cold ambient temperatures. Even further, it addresses cold temperature behavior of the various geomembranes by themselves and, most importantly, the freeze-thaw cycling behavior of a large number of geomembrane sheets and their seams.

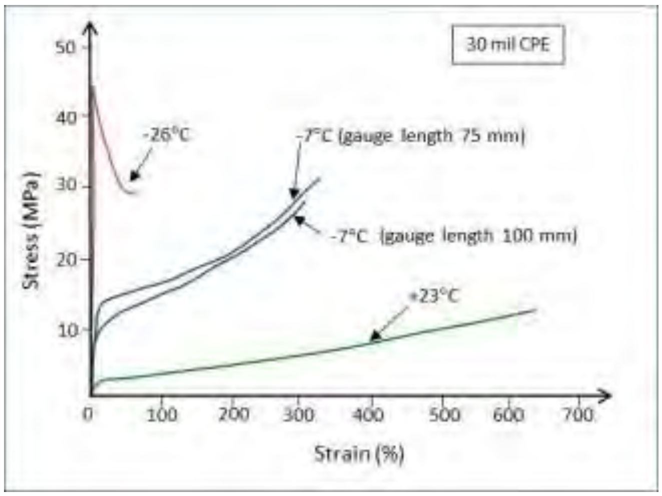
The stimulus for writing the white paper is the myriad questions that regularly come to GSI as to the potential negative effects on the tensile strength of geomembranes and their seams under cold temperature and cyclic freeze-thaw field conditions. As will be seen, the primary source for the information to be presented herein is a joint U.S. EPA/U.S. BuRec study conducted by Alice Comer and Grace Hsuan in 1996. Other companion technical information will also be presented.

Cold Temperature Behavior of Geomembranes

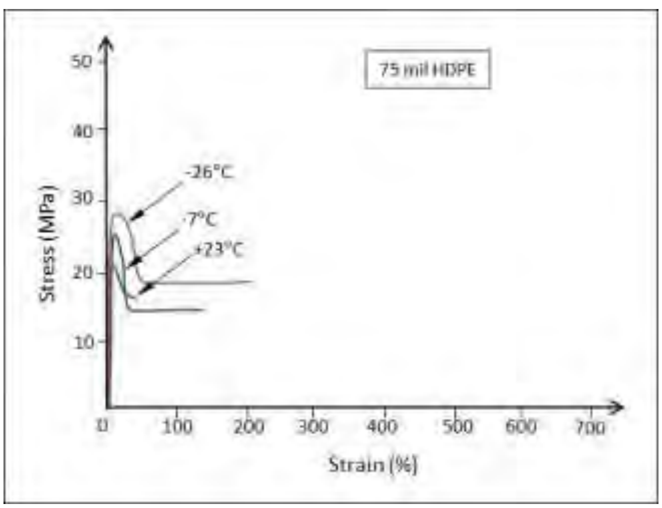
A report by Thornton and Blackall (1976) appears to be the first in describing Canadian experiences with geomembranes in cold regions. Subsequently, Rollin, et al. (1984) conducted a laboratory study on 21 types of geomembranes at temperatures down to - 35°C. They found increasing tensile strength with decreasing temperature. Richards, et al. (1985) did similar studies which also resulted in an increase in strength and a decrease in elongation with decreasing temperatures. They evaluated PVC, CPE and HDPE geomembranes and presented the stress-versus-strain curves at +23°C, -7°C and -26°C temperatures; see Figures 1a, 1b, and



(a) Tensile test results for PVC geomembranes



(b) Tensile test results for CPE geomembranes



(c) Tensile test results for HDPE geomembranes

Figure 1 – Stress-versus-strain behavior of three geomembrane types under progressively colder testing environments, Richards, et al. (1985)

1c. Here one can readily observe how the sets of curves transition from relatively ductile behavior at +23°C, to relatively brittle behavior at -26°C, with the intermediate behavior at -7°C. There are a few outliers, but the trends are undeniable. This general behavior was confirmed by Peggs, et al. (1990) and Giroud, et al. (1993), the latter working with both smooth and textured HDPE geomembranes.

While this type of thermal behavior is of interest, such information for a specific type of geomembrane must be obtained by performing or commissioning individual tests so as to obtain actual design information. Such individual testing is required due to the uniqueness of each polymer type and its specific formulation. Additives such as plasticizers, fillers, antioxidants, carbon black, colorants, etc., can influence the results to varying degrees. Even the resins themselves have behavioral differences at different temperatures. For example, the glass transition temperature of propylene is -7°C, below which the polymer is glassy and above which it is characterized as rubbery. In such a case the tensile properties are greatly influenced, as well as the material's creep and stress relaxation behavior.

There are other aspects of cold temperatures on geomembranes that go beyond the scope of this white paper. In particular are cases of impact shuttering failures in cold climates and installation concerns such as frozen subgrade, bridging, snow and ice removal and worker discomfort, Burns, et al. (1990).

Freeze-Thaw Cycling of Geomembrane Sheets and Seams

Budiman (1994) reported on both cold temperature behavior but also appears to be the first to include freeze-thaw cycling for up to 150 repetitions. He focused entirely on HDPE sheet (of different thicknesses) but not on seams. There was no degradation observed during his tests but he suggested that more cycles would be appropriate. At approximately the same time a much larger freeze-thaw study was ongoing. The final report by Comer and Hsuan was released by the U.S. Bureau of Reclamation in 1996. Related papers leading up to this final report are Hsuan, et al. (1993), Comer, et al. (1995), and Hsuan, et al. (1997). Their combined study involved 19 different geomembrane sheet materials and 31 different seam types. Furthermore, seven different resin types were evaluated. The resin types were the following:

- polyvinyl chloride (PVC)
- linear low density polyethylene (LLDPE)
- high density polyethylene (HDPE)
- flexible polypropylene (fPP)
- chlorosulfonated polyethylene (CSPE)
- fully crosslinked elastomeric alloy (FCEA)

All except FCEA are currently available, however, changes in additives and formulations have occurred and will likely to do so in the future. The entire study was conducted in four discrete parts although the fourth part was focused on induced tensile stress and stress relaxation and is not the specific purpose of this white paper. See Table 1 for the relevant three parts of their study.

Table 1 – Experimental Design of Different Parts of Comer and Hsuan (1996) Study

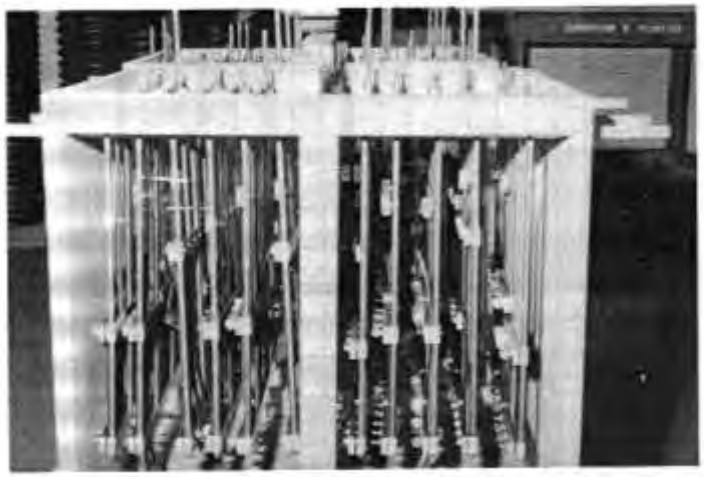
Part	Cyclic Temperature Range	Maximum Cycles	Incubation Condition	Tensile Test Temperature
I	+20°C to -20°C	200	relaxed	+20°C
II	+20°C to -20°C	200	relaxed	-20°C
III	+30°C to -20°C	500	constrained	+20°C

Part I consisted of 19 sheet materials and 27 seams. They underwent freeze-thaw cycles at +20°C for 8 hours and then -20°C for 16 hours. Tensile tests were then conducted at +20°C after 1, 5, 10, 20 50, 100 and 200 cycles.

Part II consisted of 6 sheet materials and 13 seams. They also underwent freeze-thaw cycling at +20°C for 8 hours and then -20°C for 16 hours. Different in this regard was that tensile tests were then conducted at -20°C after 1, 5, 10, 20, 50, 100 and 200 cycles. The -20°C tests were conducted in an environmental chamber (both specimens and their grips) cooled by liquid nitrogen and set at -20°C temperature.

Part III consisted of the same set of 19 sheet materials and 27 seams as in Part I but were now tensioned at a constant strain during the freeze-thaw cycling. The rack used for the tensioning is shown in Figure 2a and the assembly within the environmental chamber is shown in Figure 2b. After the targeted number of freeze-thaw cycles at +20°C for 8 hours and -20°C for 16 hours, specimens were removed and tested at +20°C after 1, 10, 50, 100, 200 and 500 cycles.

(a) Method of applying tensile load to test specimens in Part III tests



(b) Geomembrane racks in holding frame used in Part III series

Figure 2 – Method used for tensioning samples during incubation; Comer and Hsuan (1996)

Rather than showing the graphic results of the above freeze-thaw cycling study (it is available in full in the Comer and Hsuan report by the Bureau of Reclamation and the related papers by these authors) only the concluding comments will be reproduced here. They follow verbatim from the report.

Part I – Results on 200 Freeze-Thaw Cycles Tested at +20°C

- Tensile tests on geomembrane sheets: "The results show no change in either the peak strength or peak elongation of any of the tested materials".
- Shear tests on the geomembrane seams: "The results show no change in shear strength of any of the tested seam materials".
- Peel tests on the geomembrane seams: "The results show no change in peel strength of any of the tested seam materials.

Part II – Results on 200 Freeze-Thaw Cycles Tested at -20°C

- Tensile tests on geomembrane sheets: "The results show no change in either the peak strength or peak elongation of any of the tested materials".
- Shear tests on the geomembrane seams: "The results show no change in shear strength of any of the tested seam materials".
- Peel tests on the geomembrane seams: "The results show no change in peel strength of any of the tested seam materials.

Part III – Results on 500 Freeze-Thaw Cycles Tested at +20°C in a Constrained Condition

- Tensile tests on geomembrane sheets: "The results show no change in either the peak strength or peak elongation of any of the tested materials".
- Shear tests on the geomembrane seams: "The results show no change in shear strength of any of the tested seam materials".
- Peel tests on the geomembrane seams: "The results show no change in peel strength of any of the tested seam materials.

Conclusion and Recommendations

This two-part white paper focused initially on the cold temperature tensile behavior of the stress- versus-strain curves of several different types of geomembranes. As expected, the colder the temperature the more brittle, hence less ductile, were the response curves. Geomembranes made from PVC, CPE and HDPE were illustrated in this regard. The recommendation reached for this part of the white paper is that if a formulation-specific geomembrane under site-specific conditions is to be evaluated for its stress-versus-strain response, actual tests must be commissioned accordingly. The literature can only give general trends in this regard.

The second (and more important) part of this white paper focused entirely on freeze-thaw behavior of geomembranes and their different seam types. The U.S. Bureau of Reclamation report is extremely revealing in this regard. *The conclusion that the authors reached is that there is simply "no change" in tensile behavior of geomembrane sheets or their seams after freeze-thaw cycling.* It is felt that this conclusion in the context of their study is so impressive that it has essentially "closed the door" to further research on this specific topic. The essential question often raised in this regard, i.e., "will freeze-thaw conditions affect geomembrane sheets or their seam behavior," is answered with a resounding "NO".

References

Budiman, J. (1994), "Effects of Temperature on Physical Behavior of Geomembranes," Proc. 5th Intl. Conf. on Geosynthetics, Singapore, SEAC-IGS Publication, pp. 1093-1100.

Burns, D. E. and Pierce, S. V. (1990), "Technical Note on Cold Weather Installation of HDPE," Jour. Geotextiles and Geomembranes, Vol. 9, Nos. 4-6, pp. 457-459.

Comer, A. I. and Hsuan, Y. G. (1996), "Freeze-Thaw Cycling and Cold Temperature Effects on Geomembrane Sheets and Seams," U. S. Bureau of Reclamation Report R-96-03, March, 136 pgs.

Comer, A. I., Sculli, M. L. and Hsuan, Y. G. (1995), "Effects of Freeze-Thaw Cycling on Geomembrane Sheets and Their Seams," Proc. of Geosynthetics '95, Nashville, TN, pp. 853-866.

Giroud, J. P., Soderman, K. L. and Monroe, M. (1993), "Mechanical Design of Geomembrane Applications," Proc. of Geosynthetics '93, Vancouver, Canada, pp. 1455-1468.

Hsuan, Y. G., Sculli, M. L. and Comer, A. I. (1997), "Effects of Freeze-Thaw Cycling on Geomembranes Sheets and Their Seams – Part II Cold Temperature Tensile Behavior and

Thermal Induced Cyclic Stress," Geosynthetics '97 Conference Proceedings, Long Beach, CA, published by IFAI, pp. 201-216.

Hsuan, Y. G., Sculli, M. L. and Koerner, R. M. (1993), "Effects of Freeze-Thaw Cycling on Geomembranes and Their Seams," Proc. GRI-7 Conference on Geosynthetic Liner Systems: Innovations, Concerns and Designs, IFAI, Rosewell, IN, pp. 209-224.

Koerner, R. M. (20120, Designing With Geosynthetics, 6^{th} Edition, Xlibris Publ. Co., 914 pgs.

Lord, Jr., A.E., Soong, T. Y. and Koerner, R. M. (1995), "Relaxation Behavior of Thermally-Induced Stress in HDPE Geomembranes," Geosynthetics International, Vol. 2, No. 3, pp. 626-634.

Peggs, I. D., Carlson, D. S. and Peggs, S. J. (1990), "Understanding and Preventing 'Shattering' Failures of Polyethylene Geomembranes," Geotextiles, Geomembranes and Related Products, Rotterdam, Balkema.

Richards, E. A., Scott, J. D. and Chalaturnyk (1985), "Cold Temperature Properties of Geomembranes," Proc. 2^{nd} Conf. on Geotextiles and Geomembranes, Canadian Geotechnical Society, Edmonton, Alberta, pp. 121-132.

Rollin, A. L., Lafleur, J., Marcotte, M., Dascal, O. and Akber, Z. (1984), "Selection Criteria for the Use of Geomembranes in Dams and Dykes in Northern Climate," Proc. of the Intl. Conf. on Geomembranes, Denver, CO, pp. 493-499.

Thornton, D. E. and Blackall, P. (1976), "Field Evaluation of Plastic Film Liners for Petroleum Storage Areas in the Mackenzie Delta," Canadian Environmental Protection Service, Economic and Technical Review Report EPA-3-76-13.

EXHIBIT 10

GroupeCTTGroup

Geosynthetics — *Division SAGEOS* — *Géosynthétiques*

ANALYSIS REPORT
SCC Accreditation No.: 40‡

Mr Nathan Ivy
Agru America

Date: April 18, 2017
Report: S1408-005-91105B

IDENTIFICATION: HDPE Geomembrane 80 mil: G15B153050
Received: July 25, 2016; PO#: 9447-16

STANDARD:

TEST: Water Vapor Transmission of Materials — ASTM E96/E96M-13

TEST CONDITIONS:

Procedure BW (Inverted water method at 23°C) ;
Relative Humidity: 50% ;
Type of container: aluminium ;
Exposed Area: 63.62 cm² ;
Composition of sealant: Bitumen
Note 1: Calculation based on the density of liquid water ;
Tested from July 27,2016 to April 10, 2017

RESULTS:	Individual Data			**Avg.**	**S.D.**	**% CV**
Specimens thickness (mm):	2.01	2.03	2.06			
Water Vapour Transmission (g/m²·24h):	0.0102	0.00807	0.00917	**0.00915**	.00107	**11.6**
Permeance (ng/Pa/s/m²):	0.0847	0.0669	0.0761	**0.0759**	0.0089	**11.7**
Permeability, note 1 (E-15 m/s):	1.64	1.31	1.52	**1.49**	0.17	**11.2**

Prepared by: Catherine Groleau Rivard
Catherine Groleau Rivard, Tech.
Technician

Approved by: David Beaumier
For: Eric Blond, Eng., M.Sc.A.
Vice-President

Date: April 18, 2017

For any information concerning this report, please contact Eric Blond

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GroupeCTTGroup
Division SAGEOS
Geosynthetics *Géosynthétiques*

ANALYSIS REPORT
SCC Accreditation No.: 40‡

Mr Nathan Ivy
Agru America

Date: April 18, 2017
Report: S1408-005-91105B

IDENTIFICATION: HDPE Geomembrane 80 mil: G15B153050
Received: July 25, 2016; PO#: 9447-16

STANDARD:

TEST: Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor — ASTM F1249-13 Mod.

TEST CONDITIONS: Deviation from the standard: Detector used "Coulometric Sensor", allowing measurements of the WVTR of barrier materials from 5E-04 g/m²/day to 5 g/m²/day;
2 test specimens / product;
Apparatus: Mocon Aquatran Model 1;
Carrier gas: Nitrogen;
Conditioning (h): 8
Test temperature (°C): 23.0
Humid condition - Test humidity (%): 50;
Dry condition: Test humidity (%): 0;
Test area (cm²): 50 ;
The calculation of the permeability is based on the density of liquid water ;
Tested from November 2 to 14, 2016

RESULTS:	Individual Data		Avg.	S.D.	% CV
Time required to reach equilibrium (h):	224	208			
Thickness (mm):	2.004	2.03	**2.02**	0.02	**0.9**
Water Vapor Transmission Rate (g/m²/day):	0.0114	0.0107	**0.0111**	0.0005	**4.5**
Water Vapor Transmission Rate (g/100in²/day):	0.0007	0.0007	**0.0007**	0.0000	**0.0**
Permeability, note 1 (E-15 m/s):	1.83	1.74	**1.79**	0.06	**3.6**

Prepared by: Nora Boudjedaïmi, Technician

Approved by: David Beaumier
For: Eric Blond, Eng., M.Sc.A.
Vice-President

Date: April 18, 2017

For any information concerning this report, please contact Eric Blond

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GroupeCTTGroup

Geosynthetics — Division SAGEOS — Géosynthétiques

ANALYSIS REPORT
SCC Accreditation No.: 40‡

Mr Nathan Ivy
Agru America

Date: April 18, 2017
Report: S1408-005-91105B

IDENTIFICATION:	HDPE Geomembrane 80 mil: G15B153050 Received: July 25, 2016; PO#: 9447-16	
STANDARD:		
TEST:	Density and Specific Gravity (Relative Density) of Plastics by Displacement	ASTM D792 - 13 Method A
TEST CONDITIONS:	Test method A; Temperature of water (°C): 23.4 Tested August 11, 2016	

RESULTS:	Individual Data		Avg.	S.D.	% CV
Density (g/cm³):	0.949	0.949	**0.949**	0.000	**0.0**

Prepared by: Nancy Désautels
Nancy Désautels,
Technician

Approved by: David Beaumier
For: Eric Blond, Eng., M.Sc.A.
Vice-President

Date: April 18, 2017

For any information concerning this report, please contact Eric Blond

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EXHIBIT 11

WatershedGeo®
Unearthing Solutions

December 12, 2016

Ms. Anna Saindon
Geotechnology, Inc.
11816 Lackland Road, Suite 150
St. Louis, MO 63146
E. asaindon@geotechnology.com

Subject: Meredosia IEPA comment on ClosureTurf®

Ms. Saindon:

This letter is to confirm that the disclaimer language included in Watershed Geo's standard array of ClosureTurf documents, including installation guidelines and specifications, is intended only to limit the liability of Watershed Geosynthetics as it relates to conditions and activities beyond our direct control. Examples of these items include a design or contracting professional designing and/or installing ClosureTurf materials in a manner in which we do not support nor approve, and doing so with no communication or notice to Watershed Geo.

To be clear, ClosureTurf was developed specifically for the purpose of serving as a final closure cover system for environmental containment applications, including Municipal Solid Waste (MSW) and Coal Combustion Residuals (CCR) types of waste applications. Furthermore, more than 40 million square feet of the ClosureTurf system have been installed in a wide range of climactic and site specific conditions and in no instance have there been any problems or examples of the system not fulfilling its purpose.

With regards to the Meredosia CCR project, Geotechnology, Inc. worked directly with Watershed Geosynthetics in developing the design and specifications for the ClosureTurf system on this project. Those activities confirm the Meredosia CCR Closure project represents a typical application perfectly suitable for the ClosureTurf system. One item to note is the attached ClosureTurf Product Data Sheet represents the most current version and should be submitted with the project documents.

If you or anyone else involved in this process has any questions or wishes to discuss this in further detail, please feel free to contact me directly. Thank-you.

Sincerely,

Paul C. O'Malley
Vice-President, Sales
Watershed Geosynthetics, LLC

Attachments: Product Data Sheet – ClosureTurf® with 50 mil Super Gripnet

Closure *Turf*® w/50 mil SuperGripnet®

ClosureTurf

Product Data	Test Method	LLDPE Values	HDPE Values
Thickness (nominal), mil (mm)	ASTM D5994	50 (1.25)	50 (1.25)
Thickness (min. avg.), mil (mm)	ASTM D5994	47.5 (1.19)	47.5 (1.19)
Thickness (lowest indiv.), mil (mm)	ASTM D5994	42.5 (1.06)	42.5 (1.06)
Drainage Stud Height (min. avg.), mil (mm)	ASTM D7466	130 (3.30)	130 (3.30)
Friction Spike Height (min. avg.), mil (mm)	ASTM D7466	175 (4.45)	175 (4.45)
Density, g/cc	ASTM D792, Method B	0.94 (max.)	0.94 (min.)
Tensile Properties (avg. both directions)	ASTM D6693, Type IV		
Strength @Yield (min. avg.), lb/in. width (N/mm)	ASTM D6693, Type IV	N/A	110 (19.3)
Elongation @ Yield (min. avg.), % (GL=1.3 in.)	ASTM D6693, Type IV	N/A	13
Strength@Break (min. avg.), lb./in. width (N/mm)	ASTM D6693, Type IV	105 (18.4)	110 (19.3)
Elongation@Break (min. avg.), lbs. %(GL=2.0 in.)	ASTM D6693, Type IV	300	200
Tear Resistance (min. avg.), lbs. (N)	ASTM D1004	30 (133)	38 (169)
Puncture Resistance (min. avg.) lbs. (N)	ASTM D4833	55 (245)	80 (356)
Carbon Black Content (range %)	ASTM D 4218	2-3	2-3
Carbon Black Dispersion (Category)	ASTM D5596	Only near spherical agglomerates for 10 views in Cat. 1 or 2	
Stress Crack Resistance (Single Point NCTL), hours	ASTM D5397, Appendix	N/A	500
Oxidative Induction Time, minutes	ASTM D3895, 200°C, 1 atm O_2	≥140	≥140

Agru America's geomembranes are certified to pass Low Temp. Brittleness via. ASTM D746 (-80°C), and Dimensional Stability via. ASTM D1204 (± 2% @ 100°C)

ENGINEERED TURF COMPONENT

Product Data	Test Method	Values
CBR Puncture	ASTM D6241	800 lb. (MARV)
Tensile Product (MD/XD)	ASTM D4595	1,000 lb./ft. min. (MARV)
Rainfall Induced Erosion	ASTM D6459	0.04% Infill Loss 6 in./hr.
Aerodynamic Evaluation	GTRI Wind Tunnel	120 mph with max. uplift of 0.12 lb/sf
Engineered Turf Fiber UV Stability	ASTM G147	>60% retained tensile strength at 100 yrs. (projected)
Backing System UV Stability (Exposed)	ASTM G1545 Modified Cycle 1.UVA340	110 lbs./ft. retained tensile strength at 6500 hrs (projected)
Steady State Hydraulic Overtopping (ClosureTurf® w/ HydroBinder®)	ASTM D7277/D7276	5 ft. overtopping resulting in 29 ft/s velocity and 8.8 psf shear stress for Manning's N Value of 0.02
Full Scale Wave Overtopping Test Cumulative Volume (ClosureTurf® with HydroBinder®)	Colorado State University Wave Simulator	165,000 ft^3/ft
Full Scale Wave Overtopping Test Discharge (ClosureTurf® with HydroBinder®)	Colorado State University Wave Simulator	4.0 ft^3/s/ft
Internal Friction of Combined Components	ASTM D5321	35°, min.
ArmorFill™ Infill	ASTM D6913	ASTM C-33 Fine Aggregates w/ Pozzolanic Binder
Yarn Weight (Total Product Weight)	ASTM D5261	19 oz. / sq. yd. (25 oz. / sq. yd. ± 1 oz.)
Tensile Strength of Yarn	ASTM D2256	15 lbs. min.

SUPPLY INFORMATION (Standard Roll Dimensions)

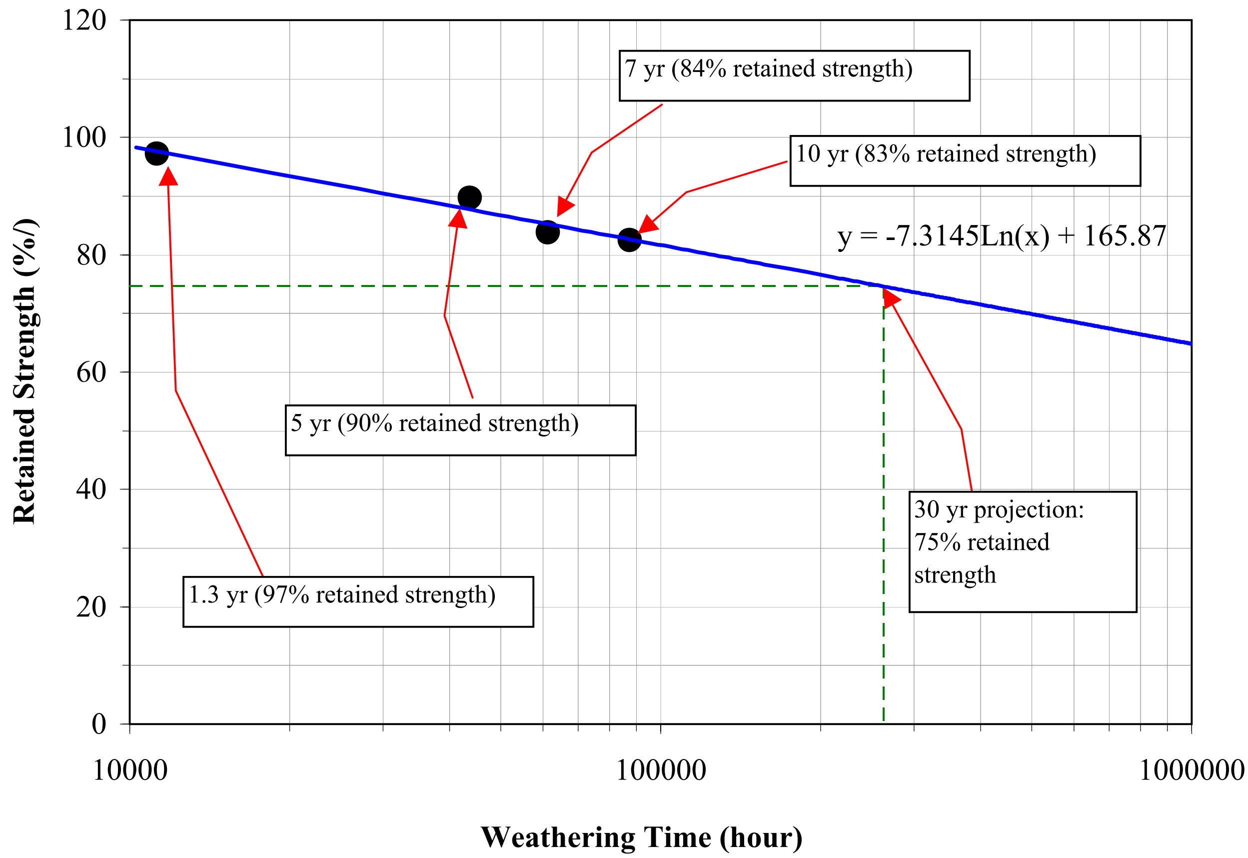
	Thickness		Width		Length		Area (approx.)		Weight (avg.)	
	mil	mm	ft.	m	ft.	m	ft^2	m2	lbs	kg
Super Gripnet®	50	1.25	23	7	300	91.4	6,900	640	~3000	~1360
Turf Component	N/A	N/A	15	4.6	300	91.4	4500	418	840	381

06-2016-2

EXHIBIT 12

CLOSURE TURF LLC -LANDFILL COVER SYSTEM
RETAINED TENSILE STRENGTH VS. WEATHERING TIME

Artificial Grass (Green Fibrillated Yarn)
Desert Weathering, New River, Arizona
Direct 45 Deg South, Plywood Backing



Weathered ClosureTuff™ Sample #1	Test Specimen	Weathering Time (year)	Weathering Time (hours)	Tensile Strength Control (lbs/in.)	Tensile Strength Weathered (%)	Observation (-)
1	Top Portion 2" long Artificial Grass	1.3	11280	25.4	97.2	
2		5.0	43800	20.2	89.7	
3		7.0	61320	20.2	83.8	
4		10.0	87600	20.2	82.5	

Projected Retained Strength at 60 years (%): **70**

DATE REPORTED:	9/12/2012
FIGURE NO.	1
PROJECT NO.	SGI11030
DOCUMENT NO.	
FILE NO.	

SGI TESTING SERVICES, LLC

EXHIBIT 13

July 8, 2010

Mr. Michael R. Ayres, P.E.
Closure Turf, LCC
3005 Breckinridge Blvd.
Duluth, GA 30096

Subject: **Aerodynamic Evaluations of Closure Turf Ground Cover Materials**

References: **1: Contract # AGR DTD 5/14/10**

Dear Mr. Ayres and Closure Turf LCC affiliates:

The Georgia Tech Research Institute is pleased to submit the attached Report, covering the period from May 14 to July 8, 2010, in fulfillment of Reference. This document details the tasks and analysis made on contracted work performed by the GTRI Aerospace, Transportation and Advanced Systems Laboratory and its team members on Phase I of the Project entitled “Aerodynamic Evaluations of Closure Turf Ground Cover Materials”.

We look forward to continuation of this work for/with Closure Turf, LCC upon the adoption of Phase II activities related to aerodynamic investigation of Closure Turf Material or other desired evaluations.

Sincerely,

Graham M. Blaylock
Principal Investigator

Aerodynamic Evaluations of Closure Turf Ground Cover

Phase I REPORT

May 14 – July 8, 2010

Project Expires: August 14, 2010

Contract No. AGR DTD 5/14/10

Proposal No. ATASL-AATD-10-1119

GTRI Project No. D-6244

Prepared for:

Mr. Michael R. Ayres, P.E.
Closure Turf, LCC
3005 Breckinridge Blvd.
Duluth, GA 30096

Prepared by:
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Principal Investigator: Graham M. Blaylock, Research Engineer II
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Introduction

GTRI has been contracted by Closure Turf, LCC to **experimentally evaluate the aerodynamic properties and ballast requirements** of a novel synthetic ground-cover system under a range of wind speed conditions (V_{inf}). The Closure Turf Material was tested full-scale in **GTRI's subsonic Model Test Facility (MTF) wind tunnel** wherein the normal force loading (lb_f/ft^2) and the shear stress (lb_f/ft^2) were determined for a suitable section of the material. The turf material was tested in two configurations, one representing the perimeter of the turf installation (Fig 5) and the 2nd at a representative interior section (Fig 6). Both installations were evaluated on a **flat level surface**. The installation is shown in Figures 1a-d below.

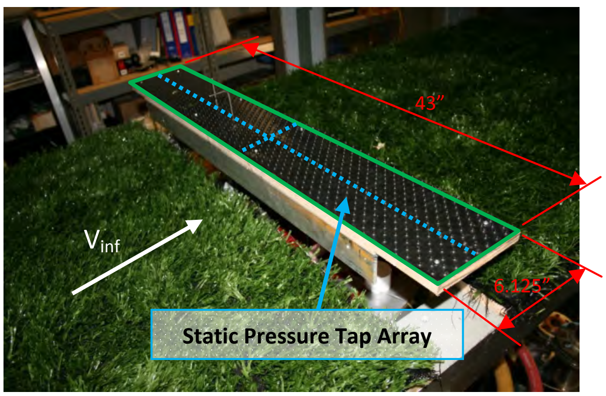

Figure 1a – Model Before Final Turf Layer

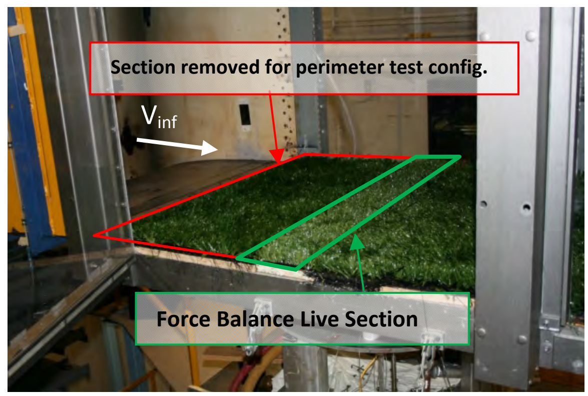

Figure 1b – Turf Installed & Model Lowered

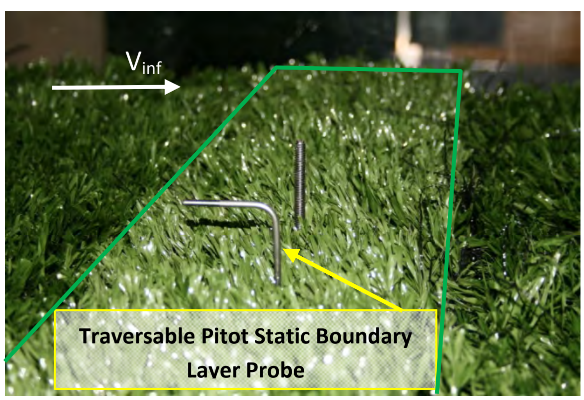

Figure 1c - Pitot Static Boundary Layer Probe

Figure 1d – Full Installation Looking Downstream

Program Description

Closure Turf system - The Closure Turf ground cover system consists of two independent layers. The first layer is a **geomembrane** to cap the upper soil layer. This is then covered with a **geotextile** turf layer (Fig 2a and 2b)

Geomembrane Layer -The impermeable geomembrane is made from Agru 50-mil LLDPE Super Gripnet® material and is used to cap the terrain being covered. It has an array of spikes to interface to the soil below and an array of studs to interface with the turf covering above. Throughout the testing and subsequent analysis of the Closure Turf system, **it was assumed that the geomembrane will be sufficiently installed to prevent movement of that layer.**

Geotextile Turf Layer – This component is designed to be installed on top of the geomembrane. The turf is intended to remain in place without an anchoring system linking it to the geomembrane below. It relies on the interface friction and sand ballast added on top of the turf to ensure that it remains immobile under all environmental conditions. It is constructed of two permeable sheets of woven HDPE mesh material which are linked together with synthetic blades of grass that are looped through the two HDPE substrates (Fig 2a).

Figure 2a – Closure Turf Synthetic Ground Cover System

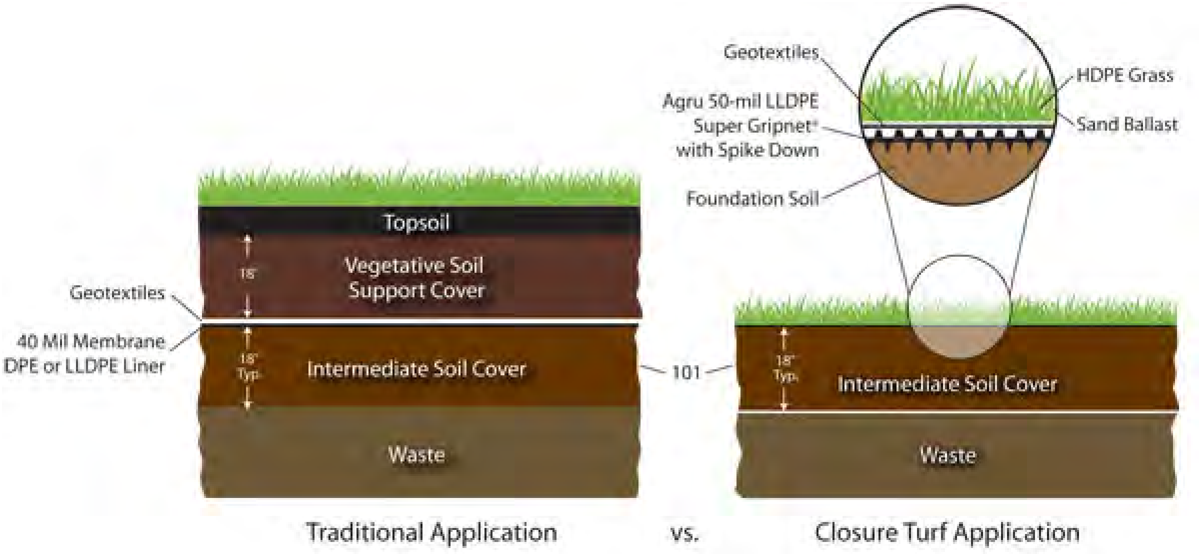

Figure 2b – Installation of Closure Turf

Purpose – The scope of this program was to conduct a full-scale wind tunnel test and experimentally isolate and measure the aerodynamic forces acting on a section of the permeable upper geotextile turf layer alone as installed above the impermeable geomembrane. The wind tunnel install configuration would simulate a wide range of wind speeds flowing over a **flat and level terrain installation** of the Closure Turf ground cover system (Fig 1a-d). The sand ballast requirements needed to counteract the resulting aerodynamic forces could then be determined. The purpose of the ballast is twofold. It serves to prevent both lift-off and tangential motion of the turf material along the geomembrane underlayment **resulting from aerodynamic lift and drag acting on the turf layer**.

Methodology

Model Design – The model represented a full-scale 2D section of the Closure Turf material with a 6.125" chord (stream-wise dimension) with a width of 43" that spanned the tunnel wall to wall. This area constituted the live balance section upon which the total sum of all aerodynamic forces could be measured by a 6 component force balance located under the test section. The model consisted of 4 layers listed below from the lower to uppermost turf layer

1) ¾" Furniture grade plywood support base – This incorporated several pressure taps on the underside in order to measure the ambient pressure (P_{amb}) to determine the vertical force (F_{amb}) due to pressure acting upward on the lower surface of the model.
2) Foam Filler Layer – This represented the soil layer surrounding the lower geomembrane spikes.
3) Impermeable Goemembrane Layer – This was fixed rigidly to the base. An array of static pressure taps was installed on the upper side of this layer, shown schematically in Fig. 1a. These

pressures were integrated numerically to determine the force (F_{geo}) due to pressure acting down on the membrane.

4) Geotextile Turf Layer – The turf was first mounted to a thin wire support frame to maintain the geometry and to provide a safety measure to prevent material from dislodging in the tunnel. The frame was then mounted rigidly on top of the lower construction flush with the top of the geomembrane upper surface studs.

Pitot Static Boundary Layer Probe – In general, pressure variation through the height of the boundary layer is due to viscous forces which cause deficits in the total pressure as the bounding flat and level surface is approached. The static pressure remains constant. However, the unique characteristics of the flexible and permeable turf layer warranted investigating the boundary layer formation on the Closure Turf system. To accomplish this, a traverse system was built into the model to actuate a Pitot static probe vertically through the boundary layer (Fig 1c). This allows the measurement of the total and static pressure as a function of the probe height, defined as h = 0" at the upper surface of the turf HDPE woven mesh. From these measurements the flow velocity distribution was determined. This characterizes the shape of the boundary layer which is by its nature a transition from the no slip condition at the surface ($V = 0$) to free stream conditions ($V = V_{inf}$). The characteristics of this boundary layer profile such as the BL thickness, the height required for the flow to reach free stream velocity, provide valuable insight into the observed results.

Force Balance – An under floor 6 component force balance was utilized to measure the aerodynamic lift (L) and the total drag (D) of the model. These forces were transmitted to the balance through a vertical strut which mounted to the underside of the model base. It should be noted that these forces represent the total sum of all pressure distributions acting on the model resolved vertically and tangentially. As such the isolated vertical force acting on just the turf layer (L_{turf}) is found by Equation 1.

$$L_{turf} = L - L_{amb} + L_{geo} \quad \text{(Eq 1)}$$

Under the confines of this program, it was not feasible to separate the drag acting on just the turf from skin friction and pressure drag acting on the geomembrane. That being the case, the total drag as measured from the force balance was taken as the drag acting on the turf. This results in a conservative overestimation of the actual turf drag force present.

Installation Conditions – Two installation conditions were examined separately. To more accurately simulate the actual installation conditions, both geomembrane and turf layers were installed upstream and downstream of the balance live model (Fig 1b and 1d). This represents an **interior** condition and in this case the model was located approximately 18" inboard of the **perimeter**. It was also suspected that the perimeter, if unaccounted for, could lead to a worse case situation. To determine the nature of this the upstream turf was removed leaving just the geomembrane as a stand in for a typical surface soil roughness that could be expected at the edge of a real world installation. This left the model mounted turf exposed at the leading edge.

Results and Discussion

These results represent the required thickness of sand for the Closure Turf system as installed on **flat and level terrain**. The density of the sand was provided by Closure Turf. If a different material density is to be used as ballast, the results can be recalculated via Equation 2.

In all cases, **the driving parameter for the depth of the sand is tangential slip due to the aerodynamic formation of shear stress**. The sand ballast requirements have been illustrated in Figures 5 and 6 for several assumed representative interface coefficients of static friction (μ_s). The **minimum** required sand ballast height is found by Equation 2.

$$h_{sand}(in) = \frac{1}{\rho_{sand}}\left(\frac{\tau}{\mu_s} + P\right)\frac{12in}{ft} \qquad \text{(Eq 2)}$$

Where:

$$\rho_{sand} = Weight\ Density\ of\ Ballast(sand) = 110\ \frac{lb_f}{ft^3}$$

$$\tau = \frac{D}{Area} = Shear\ Stress, \frac{lb_f}{ft^2}$$

$$P = \frac{L_{turf}}{Area} = Normal\ Force\ Loading, \frac{lb_f(+tve\ up)}{ft^2}$$

The measured data for determining the sand depth are shown in Table I and Table II and plotted in Figures 5 and 6 for the perimeter and interior configurations respectively. The last column of each table gives the resulting sand height requirement, based on Equation 2, for μ_s = 0.93. This value was determined independently from the efforts of this program by Closure Turf affiliates and supplied for use in this analysis.

Perimeter Condition (PC) – The ballast requirement resulting from this configuration are substantially greater than the interior condition. For the given μ_s =0.93 a **minimum** sand height of 0.4” or 3.6 lb_f/ft^2 is needed to provide the ballast based on the resulting shear at 175 ft/s. The lifting pressure will be satisfied by this loading as shown in Figure 4. It should be noted that the required ballast height due to uplift goes from positive to negative at around 115 ft/s. There are several factors contributing to these results.

PC Boundary Layer (BL) – The profile for the perimeter condition is shown in Figure 4 (Red Curve). One characteristic to note is that the boundary layer thickness reaches 99% of free stream velocity at a height of approximately 2”. This subjects the turf to up to 89% of the total free stream based on a max vertical blade height of 1.25”. This has several resulting effects which can be followed in Figures 3a to 3f. The cascade of effects proceeds as follows.

The blades are subject to higher velocities and thus higher increasing drag as the wind speed increases. The higher drag increases the bending of the blades back onto the mesh substrate. The effect of this has 2 **counteracting effects on the net lift**. At lower velocities (Fig3a-b) the blades are bent slightly with the flow being deflected and accelerated of over the perimeter as shown by the tufts. This flow acceleration increases the **local** velocity and lowers the local static pressure **below** that of free stream static which creates the pressure differential building up in 3a and b Additionally, in this installation, the perimeter exposes the gap between the turf and the geomembrane which allows for some uplift pressure recovery beneath the turf. However, as the free stream velocity increases, the drag is increased further by virtue of greater velocity exposure in the relatively thin boundary layer, the bending angle of the turf also increases (Fig 3b-c). This bending produces an increasing down force reaction which starts to counteract the suction created by the local flow acceleration. Simultaneously, the slightly reduced turf profile geometry (caused by the increased bending) shown in Figure 3c-d begins to reduce the relative local flow acceleration and thus also reduces the suction. This continues until the net vertical force becomes zero at about 110 ft/s (Fig 3d) and continues to decrease through Figure 3f.

Interior Condition (IC) – This condition owes its behavior to the formation of a drastically different boundary layer than the perimeter as shown by the blue profile in Figure 4. Compared to the Perimeter profile it is 25% thicker with no measurable velocity until the height is greater than 50% of the turf length (0.75”). The blades thusly experience a maximum velocity of 45% of free stream. This reduces the drag acting on the turf layer. Furthermore, the static pressure remains constant as a function of height through the BL which effectively prevents the formation of a pressure differential on the flat and level permeable turf membrane.

The cause for the deficient boundary layer is created by longer flow paths over a given surface and all boundaries grow in thickness and increase in turbulence with increasing distance. In the case of Closure Turf, the interaction of the flow with the flexible blades causes this growth to occur quite rapidly. The distance producing the profile in Fig 4 was 18” however, the effect of the growing boundary layer can be seen even in the perimeter condition development in Figures 3a –f. The Model section (highlighted in yellow) is 6.125” wide. It is clearly seen that little to no defection occurs in the turf at a distance just over 6 inches behind the perimeter edge. Thus the boundary layer at further distances than 18” and greater from the perimeter can be expected to have minimal interaction with the turf. Figure 6 shows these results by producing measurements requiring minimal ballast.

<u>Final Comments and Executive Summary</u>

GTRI was contracted by Closure Turf to determine the effective required ballast in terms of sand thickness needed to counteract the aerodynamic forces versus wind velocity acting on a permeable geotextile synthetic turf ground covering material that is to be overlaid onto an impermeable geomembrane underlayment. *It was found that in both perimeter and interior loading conditions, the shear acting on the material serves as the more demanding factor for determining the ballast.*

- **The resulting measurements represent the forces acting on the permeable Turf Layer *only*. The impermeable geomembrane layer was to be assumed immobile as a founding assumption of this program**

- **If it is determined that the static interface friction coefficient (μ_s) between the soil and the lower side of the membrane is lower than that occurring between the turf and the membrane upper surface studs, the lower μ_s should be used in Equation 2 to recalculate the sand depth required by shear. The same shear data given in Tables I & II will apply because, as discussed within the methodology section, the measured shear could not be feasibly separated between the two layers independently and thus represents their combined effect.**
- **The sand ballast depths represented in Figures 5 & 6 and Tables I & II are the Minimum depths required, the proper factor of safety has been left to be determined by Closure Turf, LCC and the authorized building permit issuing agencies.**
- **The perimeter of the turf installation is much more demanding than interior sections.**
- **All measurements were made on a rigidly constrained system. It was not within the scope of this investigation to determine what dynamic effects might occur, including gusts or erosion of sand ballast or any possible unstable perturbations.**
- **All configurations consisted of flat and level terrain installation.**
- **All calculations and measurements assume that the blade length is increased to account for any added ballast material. This is to ensure that the installation matches the conditions as tested.**

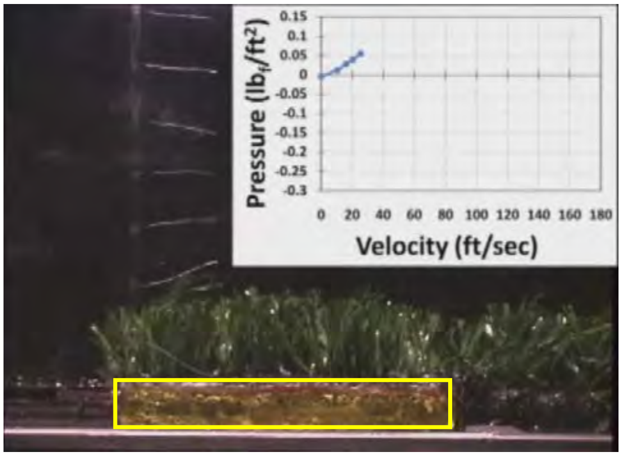

Figure 3a: Vinf = 25 ft/sec

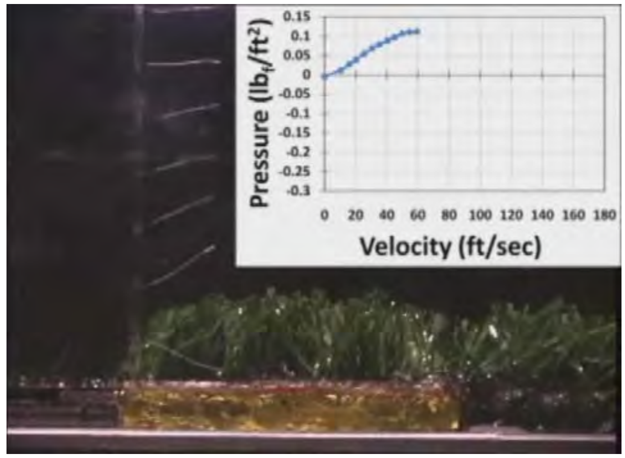

Figure 3b: Vinf = 60 ft/sec

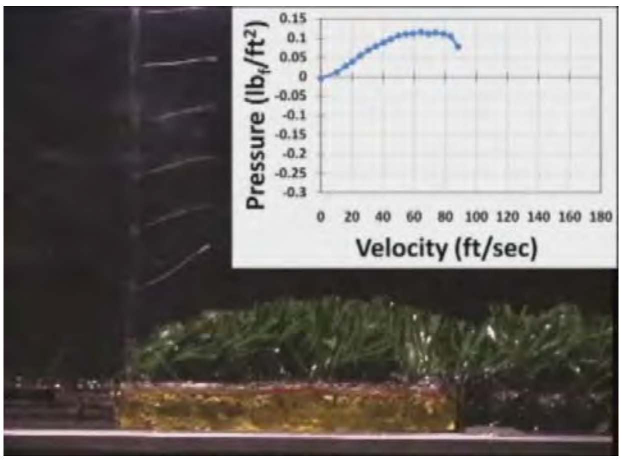

Figure 3c: Vinf = 90 ft/sec

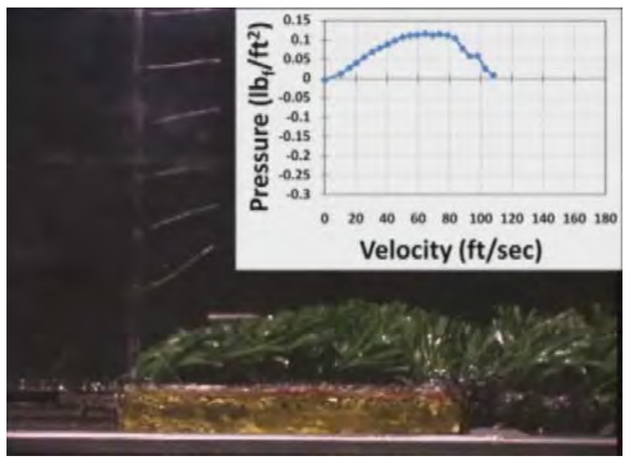

Figure 3d: Vinf = 110 ft/sec

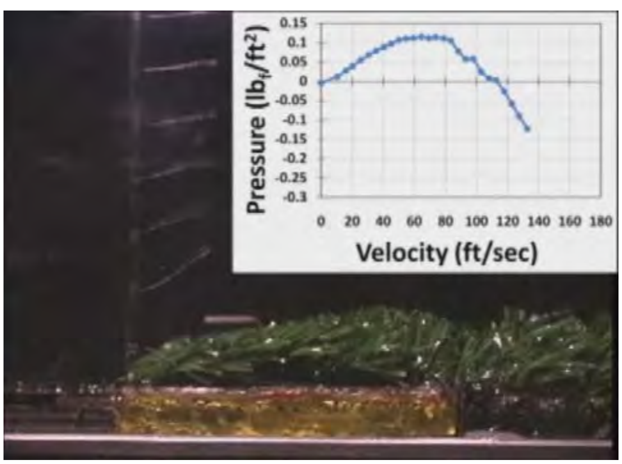

Figure 3e: Vinf = 135 ft/sec

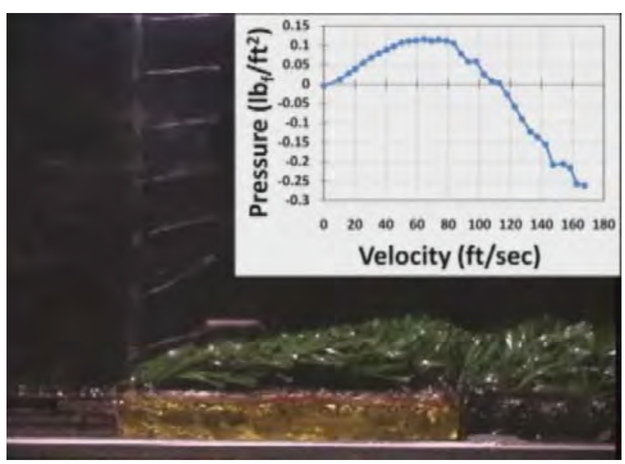

Figure 3f: Vinf = 170 ft/sec

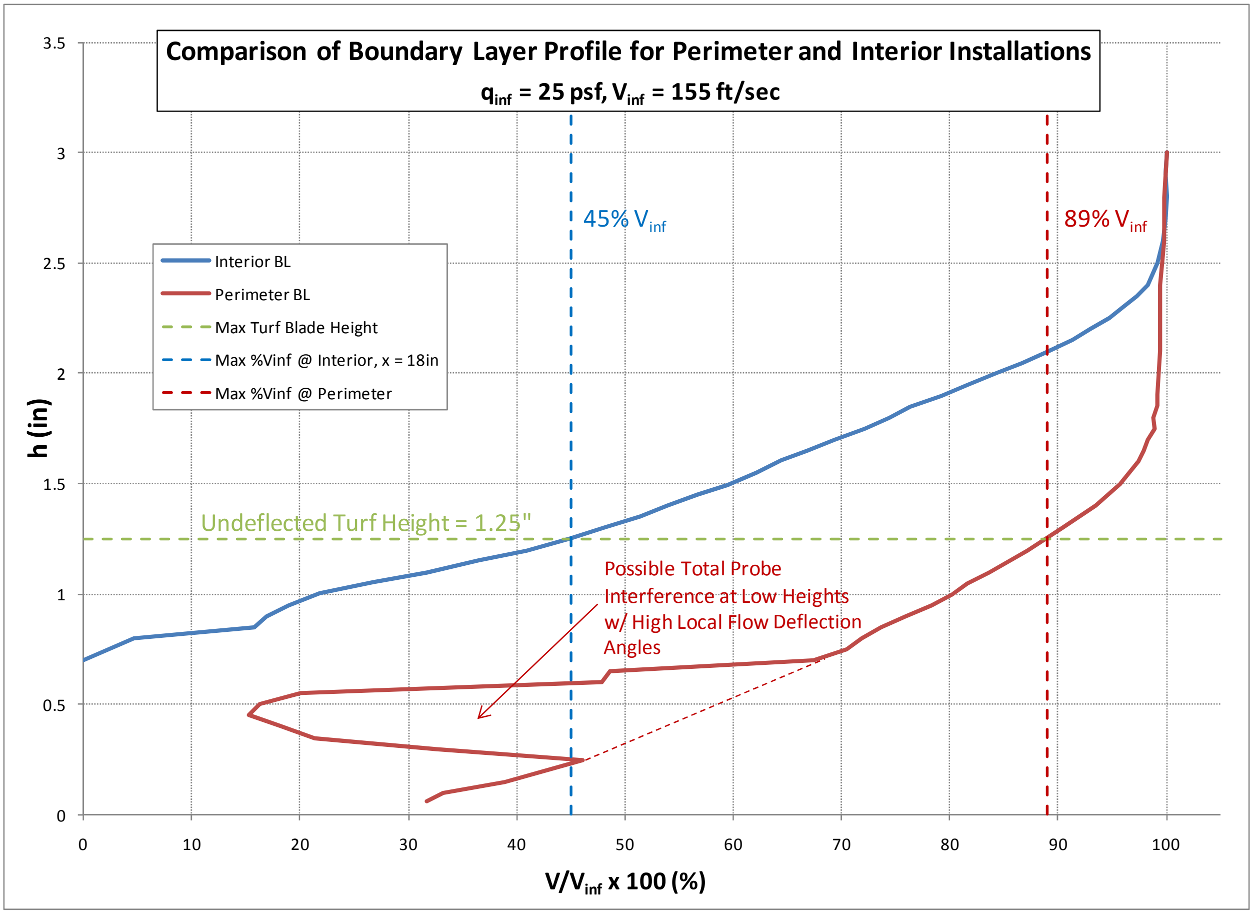

Figure 4 – Non-Dimensional Boundary Layer Profiles for Perimeter and Interior Installations

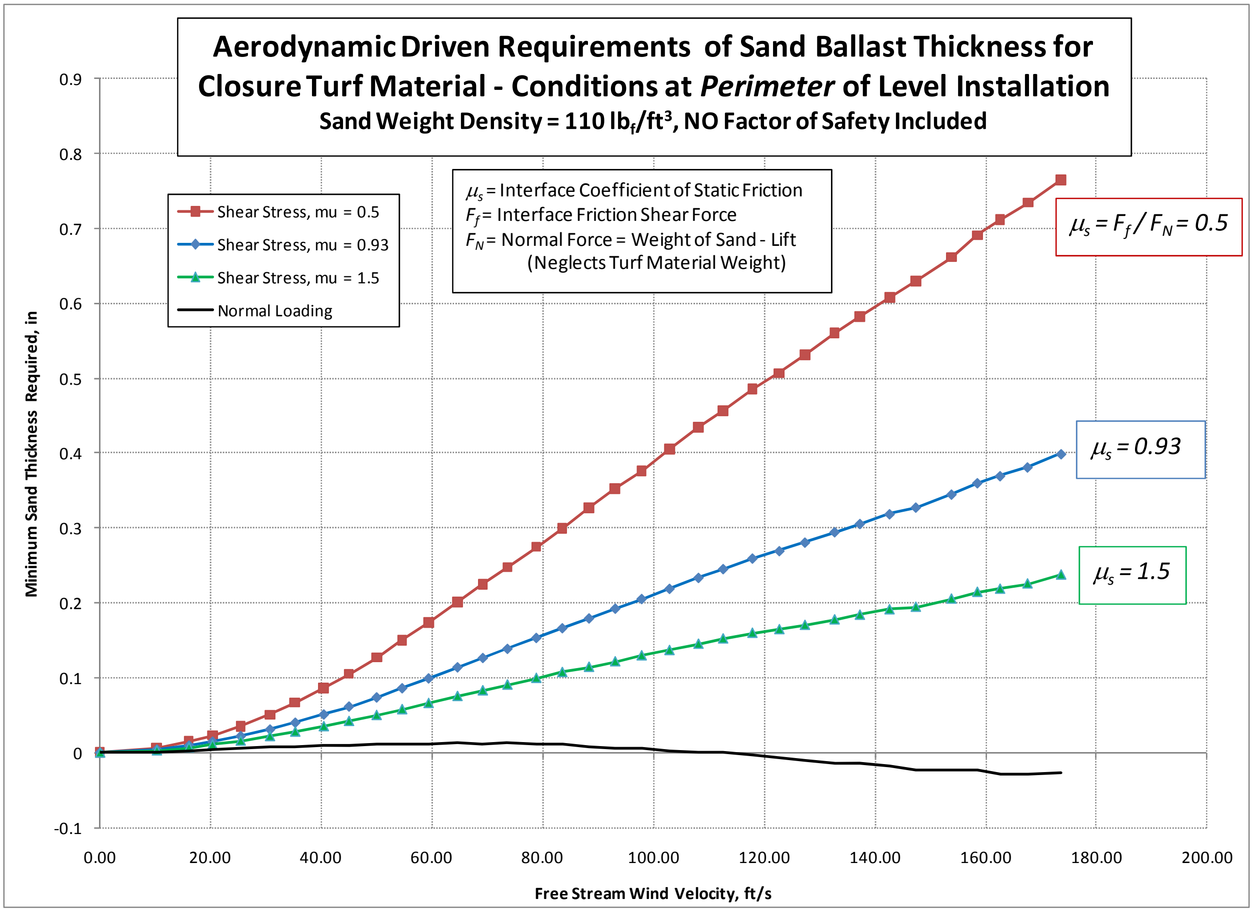

Figure 5 – Sand Ballast Minimum Requirement at the *Perimeter* of Turf Installation

Table I - Perimeter Installation				
Wind Speed (*ft/s*)	Wind Speed (*mi/hr*)	Turf Normal Force Loading (lb_f/ft^2)	Turf Shear Stress (lb_f/ft^2)	Sand Height Due to Shear (*in*)
0.00	0.00	0	0	0
10.26	6.99	0.011689	0.023784	0.0040651
16.06	10.95	0.027798	0.053106	0.009262
20.31	13.84	0.039396	0.086922	0.0144939
25.40	17.32	0.054936	0.136103	0.0219582
30.70	20.93	0.06927	0.198423	0.0308322
35.26	24.04	0.078777	0.266915	0.0399035
40.42	27.56	0.088429	0.351918	0.0509275
44.97	30.66	0.096783	0.434606	0.0615383
49.97	34.07	0.10646	0.529776	0.0737576
54.57	37.21	0.110561	0.630469	0.0860165
59.36	40.47	0.111817	0.741903	0.099225
64.58	44.03	0.115373	0.865046	0.1140578
69.15	47.15	0.111526	0.975305	0.1265718
73.60	50.18	0.114496	1.076528	0.1387694
78.82	53.74	0.111457	1.204017	0.1533926
83.52	56.94	0.104976	1.320714	0.1663744
88.34	60.23	0.077354	1.458158	0.1794835
93.08	63.46	0.057303	1.588598	0.192597
97.86	66.72	0.058201	1.697814	0.2055063
102.89	70.15	0.024978	1.844449	0.2190825
108.12	73.72	0.007601	1.985703	0.2337562
112.58	76.76	0.002646	2.090641	0.2455251
117.87	80.37	-0.026041	2.237684	0.2596441
122.74	83.69	-0.058742	2.352732	0.2695721
127.36	86.84	-0.089852	2.479185	0.2810115
132.72	90.49	-0.122289	2.627843	0.2949108
137.29	93.61	-0.135769	2.734267	0.305924
142.65	97.26	-0.155489	2.863465	0.3189279
147.40	100.50	-0.208034	2.98848	0.3278602
153.84	104.89	-0.206002	3.134988	0.3452676
158.51	108.08	-0.21588	3.274285	0.3605298
162.63	110.88	-0.256805	3.392572	0.3699406
167.59	114.26	-0.261535	3.496667	0.3816351
173.66	118.41	-0.23928	3.626641	0.3993092

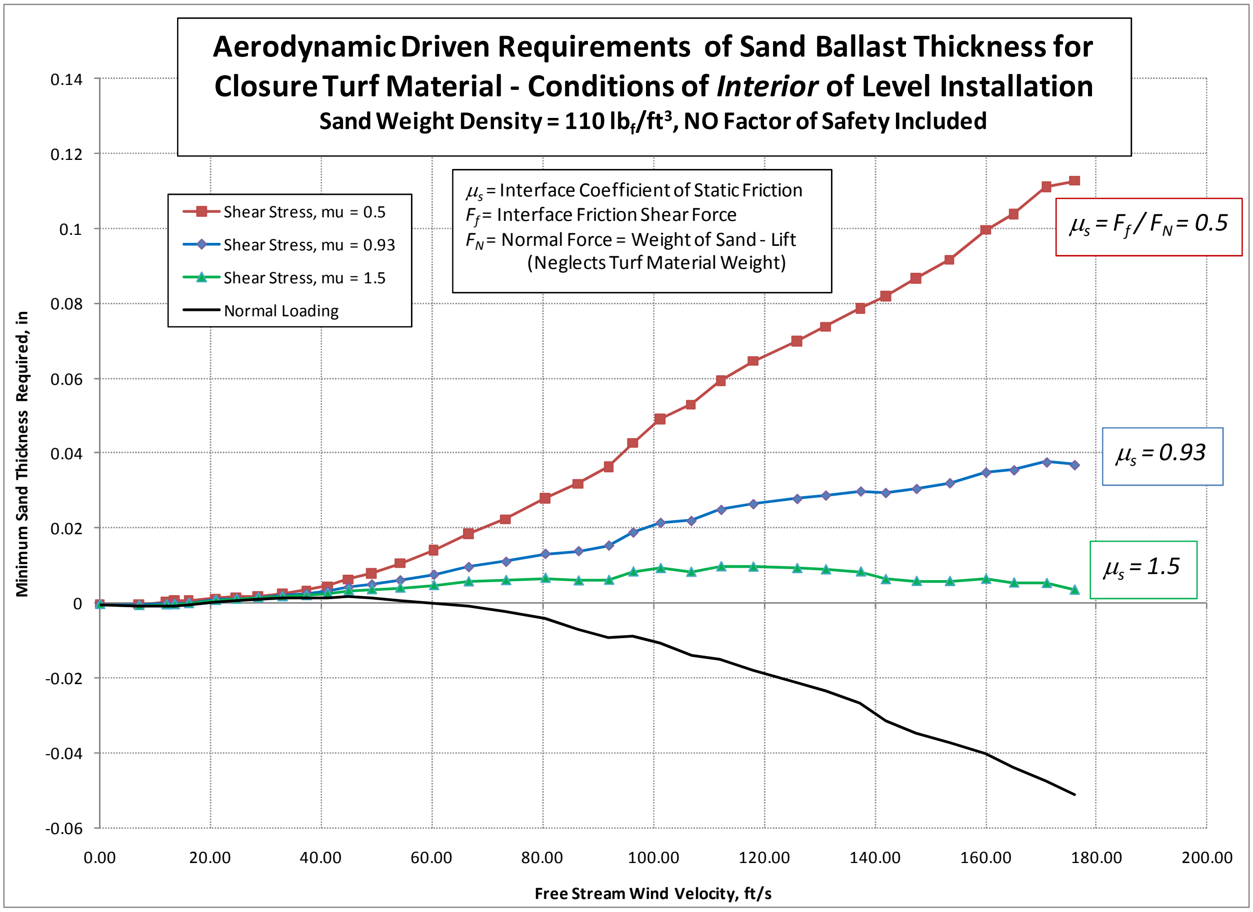

Figure 6 – Minimum Sand Ballast Requirement in the *Interior* of Turf Installation

Table I - Interior Installation

Wind Speed (ft/s)	Wind Speed (mi/hr)	Turf Normal Force Loading (lb_f/ft^2)	Turf Sheer Stress (lb_f/ft^2)	Sand Height Due to Shear (*in*)
0.00	0.00	-0.00419	0.000471	0
7.07	4.82	-0.00858	0.002819	-0.000605326
12.02	8.20	-0.00858	0.005658	-0.000272305
13.47	9.18	-0.009201	0.006927	-0.000191194
16.05	10.94	-0.005314	0.005174	2.72117E-05
20.91	14.26	0.003753	0.0034	0.000808245
24.64	16.80	0.006062	0.004099	0.00114213
28.56	19.47	0.009925	0.003388	0.001480147
32.94	22.46	0.011669	0.005393	0.001905592
37.27	25.41	0.011221	0.009767	0.002369798
41.09	28.01	0.013608	0.013502	0.003068321
44.90	30.61	0.015886	0.02088	0.004182285
49.08	33.47	0.011842	0.03072	0.004895374
54.21	36.96	0.006407	0.045273	0.006009561
60.31	41.12	-0.000648	0.064883	0.007540218
66.57	45.39	-0.006394	0.087581	0.009575904
73.32	49.99	-0.019878	0.112271	0.01100111
80.43	54.84	-0.037311	0.146631	0.013129826
86.42	58.92	-0.06477	0.178237	0.013841748
91.90	62.66	-0.083261	0.208285	0.01534924
96.30	65.66	-0.081403	0.236369	0.018846242
101.24	69.02	-0.097454	0.273298	0.021427071
106.76	72.79	-0.129489	0.30751	0.021945482
112.17	76.48	-0.138401	0.341067	0.024909568
117.97	80.43	-0.163997	0.378085	0.026459565
125.89	85.83	-0.193612	0.417441	0.027845377
131.07	89.36	-0.215792	0.445855	0.028758761
137.38	93.67	-0.245542	0.482763	0.029842691
141.88	96.73	-0.289393	0.520185	0.029448623
147.46	100.54	-0.317409	0.555461	0.030530279
153.47	104.64	-0.340708	0.59023	0.032067045
159.99	109.08	-0.369093	0.641021	0.034928388
165.05	112.53	-0.4029	0.677722	0.035545455
170.96	116.56	-0.437374	0.727691	0.037646121
176.00	120.00	-0.469865	0.751682	0.036915842

EXHIBIT 14

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GRI White Paper #6

- on -

Geomembrane Lifetime Prediction:
Unexposed and Exposed Conditions

by

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Geomembrane Lifetime Prediction: Unexposed and Exposed Conditions

1.0 Introduction

Without any hesitation the most frequently asked question we have had over the past thirty years' is "how long will a particular geomembrane last".* The two-part answer to the question, largely depends on whether the geomembrane is covered in a timely manner or left exposed to the site-specific environment. Before starting, however, recognize that the answer to either covered or exposed geomembrane lifetime prediction is neither easy, nor quick, to obtain. Further complicating the answer is the fact that all geomembranes are formulated materials consisting of (at the minimum), (i) the resin from which the name derives, (ii) carbon black or colorants, (iii) short-term processing stabilizers, and (iv) long-term antioxidants. If the formulation changes (particularly the additives), the predicted lifetime will also change. See Table 1 for the most common types of geomembranes and their approximate formulations.

Table 1 - Types of commonly used geomembranes and their approximate formulations (based on weight percentage)

Type	Resin	Plasticizer	Fillers	Carbon Black	Additives
HDPE	95-98	0	0	2-3	0.25-1
LLDPE	94-96	0	0	2-3	0.25-3
fPP	85-98	0	0-13	2-4	0.25-2
PVC	50-70	25-35	0-10	2-5	2-5
CSPE	40-60	0	40-50	5-10	5-15
EPDM	25-30	0	20-40	20-40	1-5

HDPE = high density polyethylene
LLDPE = linear low density polyethylene
fPP = flexible polypropylene
PVC = polyvinyl chloride (plasticized)
CSPE = chlorsulfonated polyethylene
EPDM = ethylene propylene diene terpolymer

* More recently, the same question has arisen but focused on geotextiles, geogrids, geopipe, turf reinforcement mats, fibers of GCLs, etc. This White Paper, however, is focused completely on geomembranes due to the tremendous time and expense of providing such information for all types of geosynthetics.

The possible variations being obvious, one must also address the degradation mechanisms which might occur. They are as follows accompanied by some generalized commentary.

- Ultraviolet Light - This occurs only when the geosynthetic is exposed; it will be the focus of the second part of this communication.
- Oxidation - This occurs in all polymers and is the major mechanism in polyolefins (polyethylene and polypropylene) under all conditions.
- Ozone - This occurs in all polymers that are exposed to the environment. The site-specific environment is critical in this regard.
- Hydrolysis - This is the primary mechanism in polyesters and polyamides.
- Chemical - Can occur in all polymers and can vary from water (least aggressive) to organic solvents (most aggressive).
- Radioactivity - This is not a factor unless the geomembrane is exposed to radioactive materials of sufficiently high intensity to cause chain scission, e.g., high level radioactive waste materials.
- Biological - This is generally not a factor unless biologically sensitive additives (such as low molecular weight plasticizers) are included in the formulation.
- Stress State – This is a complicating factor which is site-specific and should be appropriately modeled in the incubation process but, for long-term testing, is very difficult and expensive to acheive.
- Temperature - Clearly, the higher the temperature the more rapid the degradation of all of the above mechanisms; temperature is critical to lifetime and furthermore is the key to

time-temperature-superposition which is the basis of the laboratory incubation methods which will be followed.

2.0 Lifetime Prediction: Unexposed Conditions

Lifetime prediction studies at GRI began at Drexel University under U. S. EPA contract from 1991 to 1997 and was continued under GSI consortium funding until ca. 2002. Focus to date has been on HDPE geomembranes placed beneath solid waste landfills due to its common use in this particular challenging application. Incubation of the coupons has been in landfill simulation cells (see Figure 1) maintained at 85, 75, 65 and 55°C. The specific conditions within these cells are oxidation beneath, chemical (water) from above, and the equivalent of 50 m of solid waste mobilizing compressive stress. Results have been forthcoming over the years insofar as three distinct lifetime stages; see Figure 2.

Stage A - Antioxidant Depletion Time

Stage B - Induction Time to the Onset of Degradation

Stage C - Time to Reach 50% Degradation (i.e., the Halflife)

2.1 Stage A - Antioxidant Depletion Time

The dual purposes of antioxidants are to (i) prevent polymer degradation during processing, and (ii) prevent oxidation reactions from taking place during Stage A of service life, respectively. Obviously, there can only be a given amount of antioxidants in any formulation. Once the antioxidants are depleted, additional oxygen diffusing into the geomembrane will begin to attack the polymer chains, leading to subsequent stages as shown in Figure 2. The duration of the antioxidant depletion stage depends on both the type and amount of the various antioxidants, i.e., the precise formulation.

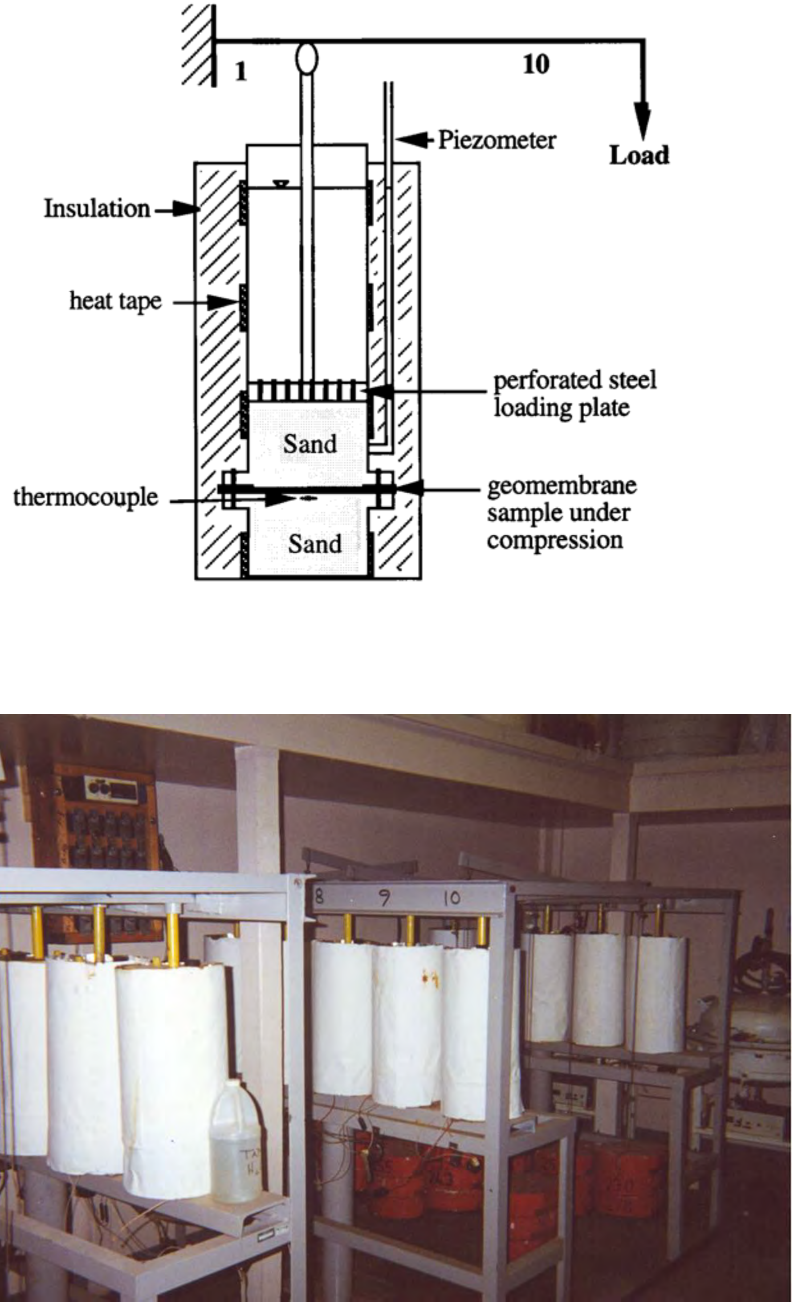


Figure 1. Incubation schematic and photograph of multiple cells maintained at various constant temperatures.

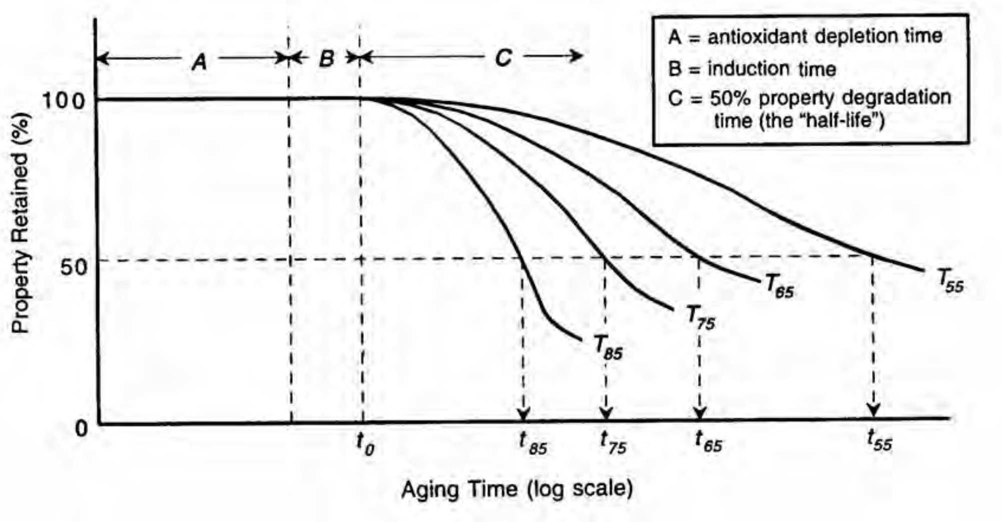


Figure 2. Three individual stages in the aging of most geomembranes.

The depletion of antioxidants is the consequence of two processes: (i) chemical reactions with the oxygen diffusing into the geomembrane, and (ii) physical loss of antioxidants from the geomembrane. The chemical process involves two main functions; the scavenging of free radicals converting them into stable molecules, and the reaction with unstable hydroperoxide (ROOH) forming a more stable substance. Regarding physical loss, the process involves the distribution of antioxidants in the geomembrane and their volatility and extractability to the site-specific environment.

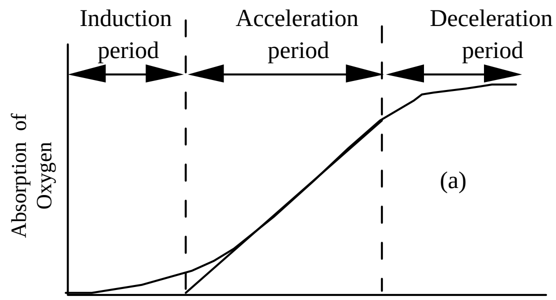
Hence, the rate of depletion of antioxidants is related to the type and amount of antioxidants, the service temperature, and the nature of the site-specific environment. See Hsuan and Koerner (1998) for additional details.

2.2 Stage B - Induction Time to Onset of Degradation

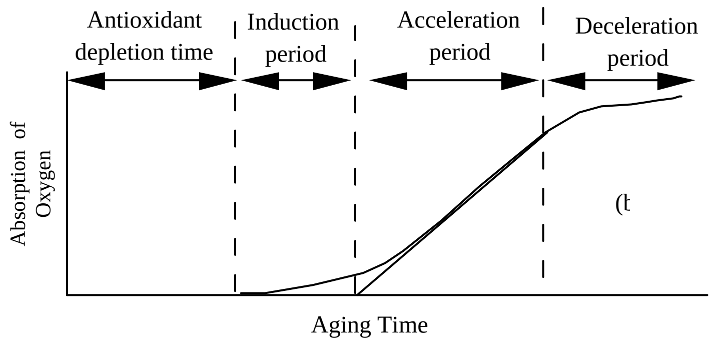
In a pure polyolefin resin, i.e., one without carbon black and antioxidants, oxidation occurs extremely slowly at the beginning, often at an immeasurable rate. Eventually, oxidation occurs more rapidly. The reaction eventually decelerates and once again becomes very slow.

This progression is illustrated by the S-shaped curve of Figure 3(a). The initial portion of the curve (before measurable degradation takes place) is called the induction period (or induction time) of the polymer. In the induction period, the polymer reacts with oxygen forming hydroperoxide (ROOH), as indicated in Equations (1)-(3). However, the amount of ROOH in this stage is very small and the hydroperoxide does not further decompose into other free radicals which inhibits the onset of the acceleration stage.

In a stabilized polymer such as one with antioxidants, the accelerated oxidation stage takes an even longer time to be reached. The antioxidants create an additional depletion time stage prior to the onset of the induction time, as shown in Figure 3(b).



(a) Pure unstabilized polyethylene



(b) Stabilized polyethylene

Figure 3. Curves illustrating various stages of oxidation.

$$RH \rightarrow R \bullet + H \bullet \quad (1)$$

(aided by energy or catalyst residues in the polymer)

$$R \bullet + O_2 \rightarrow ROO \bullet \quad (2)$$

$$ROO \bullet + RH \rightarrow ROOH + R \bullet \quad (3)$$

In the above, RH represents the polyethylene polymer chains; and the symbol "•" represents free radicals, which are highly reactive molecules.

2.3 Stage C - Time to Reach 50% Degradation (Halflife)

As oxidation continues, additional ROOH molecules are being formed. Once the concentration of ROOH reaches a critical level, decomposition of ROOH begins, leading to a substantial increase in the amount of free radicals, as indicated in Equations (4) to (6). The additional free radicals rapidly attack other polymer chains, resulting in an accelerated chain reaction, signifying the end of the induction period, Rapopport and Zaikov (1986). This indicates that the concentration of ROOH has a critical control on the duration of the induction period.

$$ROOH \rightarrow RO \bullet \; OH \bullet \text{ (aided by energy)} \quad (4)$$

$$RO \bullet + RH \rightarrow ROH + R \bullet \quad (5)$$

$$OH \bullet + RH \rightarrow H_2O + R \bullet \quad (6)$$

A series of oxidation reactions produces a substantial amount of free radical polymer chains (R•), called alkyl radicals, which can proceed to further reactions leading to either cross-linking or chain scission in the polymer. As the degradation of polymer continues, the physical and mechanical properties of the polymer start to change. The most noticeable change in physical properties is the melt index, since it relates to the molecular weight of the polymer. As for mechanical properties, both tensile break stress (strength) and break strain (elongation) decrease.

Ultimately, the degradation becomes so severe that all tensile properties start to change (tear, puncture, burst, etc.) and the engineering performance is jeopardized. This signifies the end of the so-called "service life" of the geomembrane.

Although quite arbitrary, the limit of service life of polymeric materials is often selected as a 50% reduction in a specific design property. This is commonly referred to as the halflife time, or simply the "halflife". It should be noted that even at halflife, the material still exists and can function, albeit at a decreased performance level with a factor-of-safety lower than the initial design value.

2.4 Summary of Lifetime Research-to-Date

Stage A, that of antioxidant depletion for HDPE geomembranes as required in the GRI-GM13 Specification, has been well established by our own research and corroborated by others, e.g., Sangram and Rowe (2004). The GRI data for standard and high pressure Oxidative Induction Time (OIT) is given in Table 2. The values are quite close to one another. Also, as expected, the lifetime is strongly dependent on the service temperature; with the higher the temperature the shorter the lifetime.

Table 2 - Lifetime prediction of HDPE (nonexposed) at various field temperatures

In Service Temperature (°C)	Stage "A" (years)			Stage "B"	Stage "C"	Total Prediction* (years)
	Standard OIT	High Press. OIT	Average OIT	(years)	(years)	
20	200	215	208	30	208	446
25	135	144	140	25	100	265
30	95	98	97	20	49	166
35	65	67	66	15	25	106
40	45	47	46	10	13	69

*Total = Stage A (average) + Stage B + Stage C

Stage "B", that of induction time, has been obtained by comparing 30-year old polyethylene water and milk containers (containing no long-term antioxidants) with currently produced containers. The data shows that degradation is just beginning to occur as evidenced by slight changes in break strength and elongation, but not in yield strength and elongation. The lifetime for this stage is also given in Table 2.

Stage "C", the time for 50% change of mechanical properties is given in Table 2 as well. The data depends on the activation energy, or slope of the Arrhenius curve, which is very sensitive to material and experimental techniques. The data is from Gedde, et al. (1994) which is typical of the HDPE resin used for gas pipelines and is similar to Martin and Gardner (1983).

Summarizing Stages A, B, and C, it is seen in Table 2 that the halflife of covered HDPE geomembranes (formulated according to the current GRI-GM13 Specification) is estimated to be 449-years at 20°C. This, of course, brings into question the actual temperature for a covered geomembrane such as beneath a solid waste landfill. Figure 4 presents multiple thermocouple monitoring data of a municipal waste landfill liner in Pennsylvania for over 10-years, Koerner and Koerner (2005). Note that for 6-years the temperature was approximately 20°C. At that time and for the subsequent 4-years the temperature increased to approximately 30°C. Thus, the halflife of this geomembrane is predicted to be from 166 to 446 years within this temperature range. The site is still being monitored, see Koerner and Koerner (2005).

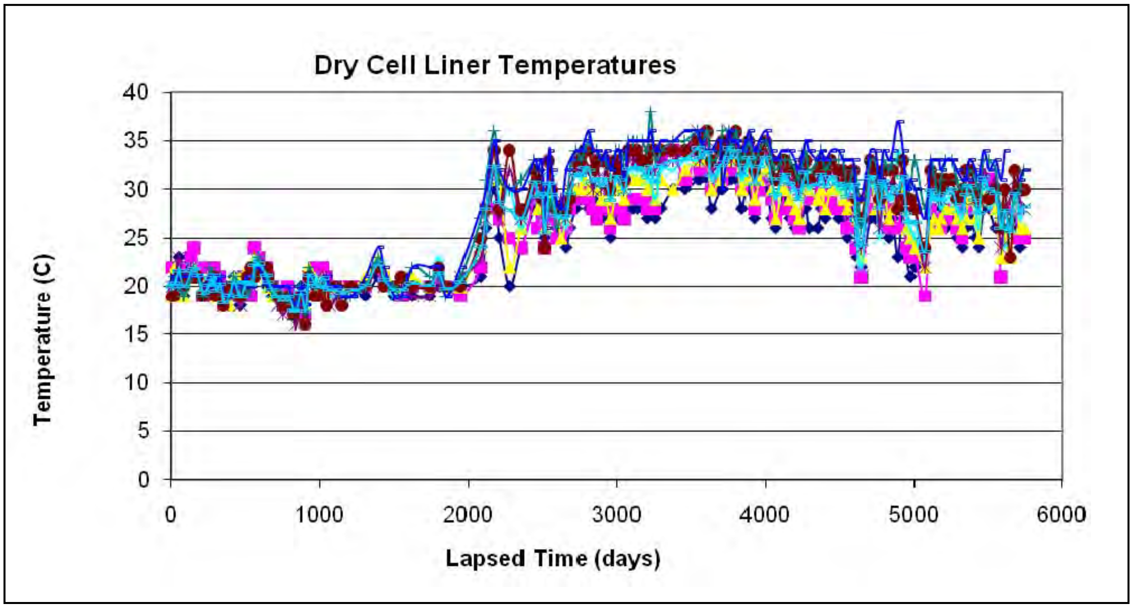


Figure 4. Long-term monitoring of an HDPE liner beneath a municipal solid waste landfill in Pennsylvania.

2.5 Lifetime of Other Covered Geomembranes

By virtue of its widespread use as liners for solid waste landfills, HDPE is by far the widest studied type of geomembrane. Note that in most countries (other than the U.S.), HDPE is the required geomembrane type for solid waste containment. Some commentary on other-than HDPE geomembranes (recall Table 1) follows:

2.5.1 Linear Low Density Polyethylene (LLDPE) geomembranes

The nature of the LLDPE resin and its formulation is very similar to HDPE. The fundamental difference is that LLDPE is a lower density, hence lower crystallinity, than HDPE; e.g., 10% versus 50%. This has the effect of allowing oxygen to diffuse into the polymer structure quicker, and likely decreases Stages A and C. How much is uncertain since no data is available, but it is felt that the lifetime of LLDPE will be somewhat reduced with respect to HDPE.

2.5.2 Plasticizer migration in PVC geomembranes

Since PVC geomembranes necessarily have plasticizers in their formulations so as to provide flexibility, the migration behavior must be addressed for this material. In PVC the plasticizer bonds to the resin and the strength of this bonding versus liquid-to-resin bonding is significant. One of the key parameters of a stable long-lasting plasticizer is its molecular weight. The higher the molecular weight of the plasticizer in a PVC formulation, the more durable will be the material. Conversely, low molecular weight plasticizers have resulted in field failures even under covered conditions. See Miller, et al. (1991), Hammon, et al. (1993), and Giroud and Tisinger (1994) for more detail in this regard. At present there is a considerable difference (and cost) between PVC geomembranes made in North America versus Europe. This will be apparent in the exposed study of durability in the second part of this White Paper.

2.5.3 Crosslinking in EPDM and CSPE geomembrnaes

The EPDM geomembranes mentioned in Table 1 are crosslinked thermoset materials. The oxidation degradation of EPDM takes place in either ethylene or propylene fraction of the co-polymer via free radical reactions, as expressed in Figure 5, which are described similarly by Equations (4) to (6).

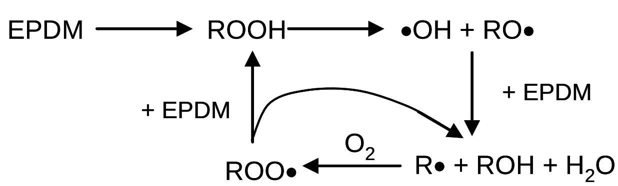


Figure 5. Oxidative degradation of crosslinked EPDM geomembranes, (Wang and Qu, 2003).

For CSPE geomembranes, the degradation mechanism is dehydrochlorination by losing chlorine and generating carbon-carbon double bonds in the main polymer chain, as shown in Figure 6.

The carbon-carbon double bonds become the preferred sites for further thermodegradation or cross-linking in the polymer, leading to eventual brittleness of the geomembrane.

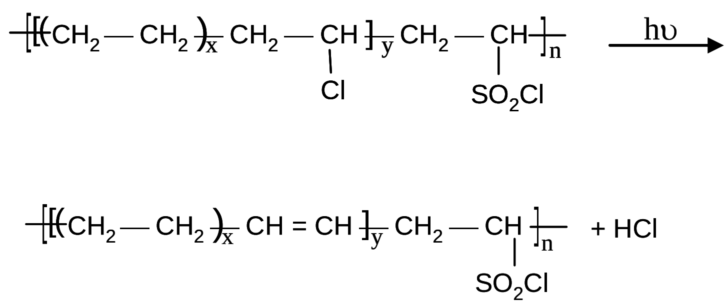


Figure 6. Dechlorination degradation of crosslinked CSPE geomembranes (Chailan, et al., 1995).

Neither EPDM nor CSPE has had a focused laboratory study of the type described for HDPE reported in the open literature. Most of lifetime data for these geomembranes is antidotal by virtue of actual field performance. Under covered conditions, as being considered in this section, there have been no reported failures by either of these thermoset polymers to our knowledge.

3.0 Lifetime Prediction: Exposed Conditions

Lifetime prediction of exposed geomembranes have taken two very different pathways; (i) prediction from anecdotal feedback and field performance, and (ii) from laboratory weathering device predictions.

3.1 Field Performance

There is a large body of anecdotal information available on field feedback of exposed geomembranes. It comes form two quite different sources, i.e., dams in Europe and flat roofs in the USA.

Regarding exposed geomembranes in dams in Europe, the original trials were using 2.0 mm thick polyisobutylene bonded directly to the face of the dam. There were numerous problems encountered as described by Scuero (1990). Similar experiences followed using PVC geomembranes. In 1980, a geocomposite was first used at Lago Nero which had a 200 g/m^2 nonwoven geotextile bonded to the PVC geomembrane. This proved quite successful and led to the now-accepted strategy of requiring drainage behind the geomembrane. In addition to thick nonwoven geotextiles, geonets, and geonet composites have been successful. Currently over 50 concrete and masonry dams have been rehabilitated in this manner and are proving successful for over 30-years of service life. The particular type of PVC plasticized geomembranes used for these dams is proving to be quite durable. Tests by the dam owners on residual properties show only nominal changes in properties, Cazzuffi (1998). As indicated in Miller, et al. (1991) and Hammond, et al. (1993), however, different PVC materials and formulations result in very different behavior; the choice of plasticizer and the material’s thickness both being of paramount importance. An excellent overview of field performance is recently available in which 250 dams which have been waterproofed by geomembranes is available from ICOLD (2010).

Regarding exposed geomembranes in flat roofs, past practice in the USA is almost all with EPDM and CSPE and, more recently, with fPP. Manufacturers of these geomembranes regularly warranty their products for 20-years and such warrants appear to be justified. EPDM and CSPE, being thermoset or elastomeric polymers, can be used in dams without the necessity of having seams by using vertical attachments spaced at 2 to 4 m centers, see Scuero and Vaschetti (1996). Conversely, fPP can be seamed by a number of thermal fusion methods. All of these geomembrane types have good conformability to rough substrates as is typical of concrete and masonry dam rehabilitation. It appears as though experiences (both positive and negative) with geomembranes in flat roofs should be transferred to all types of waterproofing in civil engineering applications.

3.2 Laboratory Weatherometer Predictions

For an accelerated simulation of direct ultraviolet light, high temperature, and moisture using a laboratory weatherometer one usually considers a worst-case situation which is the solar maximum condition. This condition consists of global, noon sunlight, on the summer solstice, at normal incidence. It should be recognized that the UV-A range is the target spectrum for a laboratory device to simulate the naturally occurring phenomenon, see Hsuan and Koerner (1993), and Suits and Hsuan (2001).

The Xenon Arc weathering device (ASTM D4355) was introduced in Germany in 1954. There are two important features; the type of filters and the irradiance settings. Using a quartz inner and borosilicate outer filter (quartz/boro) results in excessive low frequency wavelength degradation. The more common borosilicate inner and outer filters (boro/boro) shows a good correlation with solar maximum conditions, although there is an excess of energy below 300 nm wavelength. Irradiance settings are important adjustments in shifting the response although they do not eliminate the portion of the spectrum below 300 nm frequency. Nevertheless, the Xenon Arc device is commonly used method for exposed lifetime prediction of all types of geosynthetics.

UV Fluorescent devices (ASTM D7238) are an alternative type of accelerated laboratory test device which became available in the early 1970’s. They reproduce the ultraviolet portion of the sunlight spectrum but not the full spectrum as in Xenon Arc weatherometers. Earlier FS-40 and UVB-313 lamps give reasonable short wavelength output in comparison to solar maximum. The UVA-340 lamp was introduced in 1987 and its response is seen to reproduce ultraviolet light quite well. This device (as well as other types of weatherometers) can handle elevated temperature and programmed moisture on the test specimens.

Research at the Geosynthetic Institute (GSI) has actively pursued both Xenon and UV Fluorescent devices on a wide range of geomembranes. Table 3 gives the geomembranes that were incubated and the number of hours of exposure as of 12 July 2005.

Table 5 - Details of the GSI laboratory exposed weatherometer study on various types of geomembranes

Geomembrane Type	Thickness (mm)	UV Fluorescent Exposure*	Xenon Exposure*	Comment
1. HDPE (GM13)	1.50	8000 hrs.	6600 hrs.	Basis of GRI-GM13 Spec
2. LLDPE (GM17)	1.00	8000	6600	Basis of GRI-GM-17 Spec
3. PVC (No. Amer.)	0.75	8000	6600	Low Mol. Wt. Plasticizer
4. PVC (Europe)	2.50	7500	6600	High Mol. Wt. Plasticizer
5. fPP (BuRec)	1.00	2745**	4416**	Field Failure at 26 mos.
6. fPP-R (Texas)	0.91	100	100	Field Failure at 8 years
7. fPP (No. Amer.)	1.00	7500	6600	Expected Good Performance

*As of 12 July 2005 exposure is ongoing
**Light time to reach halflife of break and elongation

3.3 Laboratory Weatherometer Acceleration Factors

The key to validation of any laboratory study is to correlate results to actual field performance. For the nonexposed geomembranes of Section 2 such correlations will take hundreds of years for properly formulated products. For the exposed geomembranes of Section 3, however, the lifetimes are significantly shorter and such correlations are possible. In particular, Geomembrane #5 (flexible polypropylene) of Table 3 was an admittedly poor geomembrane formulation which failed in 26 months of exposure at El Paso, Texas, USA. The reporting of this failure is available in the literature, Comer, et al. (1998). Note that for both UV Fluorescent and Xenon Arc laboratory incubation of this material, failure (halflife to 50% reduction in strength and elongation) occurred at 2745 and 4416 hours, respectively. The comparative analysis of laboratory and field for this case history allows for the obtaining of acceleration factors for the two incubation devices.

3.3.1 Comparison between field and UV Fluorescent weathering

The light source used in the UV fluorescent weathering device is UVA with wavelengths from 295-400 nm. In addition, the intensity of the radiation is controlled by the Solar Eye irradiance control system. The UV energy output throughout the test is 68.25 W/m^2.

The time of exposure to reach 50% elongation at break was as follows:

= 2745 hr. of light
= 9,882,000 seconds

Total energy in MJ/m^2 = 68.25 W/m^2 × 9,882,000
= 674.4 MJ/m^2

The field site was located at El Paso, Texas. The UVA radiation energy (295-400 nm) at this site is estimated based on data collected by the South Florida Testing Lab in Arizona (which is a similar atmospheric location). For 26 months of exposure, the accumulated UV radiation energy is 724 MJ/m^2 which is very close to that generated from the UV fluorescent weatherometer. Therefore, direct comparison of the exposure time between field and UV fluorescent is acceptable.

Field time vs. Fluorescent UV light time: **Thus, the acceleration factor is 6.8.**
= 26 Months = 3.8 Months

3.3.2 Comparison between field and Xenon Arc weathering

The light source of the Xenon Arc weathering device simulates almost the entire sunlight spectrum from 250 to 800 nm. Depending of the age of the light source and filter, the solar energy ranges from 340.2 to 695.4 W/m^2, with the average value being 517.8 W/m^2.

The time of exposure to reach 50% elongation at break

= 4416 hr. of light
= 15,897,600 seconds

Total energy in MJ/m^2 = 517.8 W/m^2 × 15,897,600
= 8232 MJ/m^2

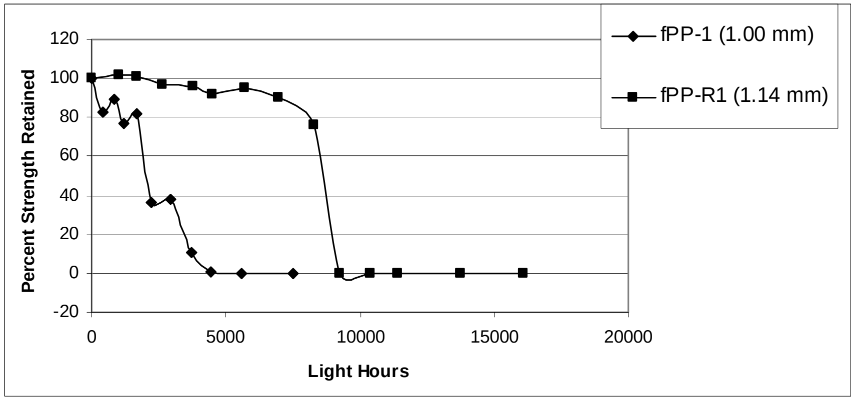
The solar energy in the field is again estimated based on data collected by the South Florida Testing Lab in Arizona. For 26 months of exposure, the accumulated solar energy (295-800 nm) is 15,800 MJ/m^2, which is much higher than that from the UV Fluorescent device. Therefore, direct comparison of halflives obtained from the field and Xenon Arc device is not anticipated to be very accurate. However, for illustration purposes the acceleration factor based on Xenon Arc device would be as follows:

Field = 26 Months	vs.	Xenon Arc = 6.1 Months	:	**Thus, the acceleration factor is 4.3.**

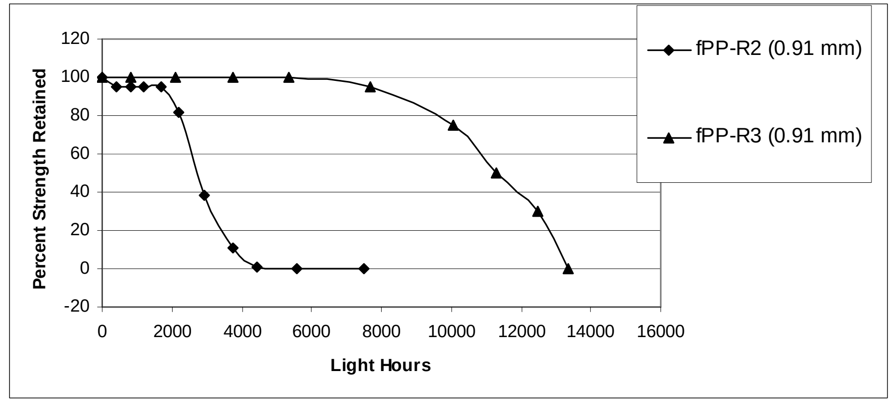
The resulting conclusion of this comparison of weathering devices is that the UV Fluorescent device is certainly reasonable to use for long-term incubations. When considering the low cost of the device, its low maintenance, its inexpensive bulbs, and ease of repair it (the UV Fluorescent device) will be used exclusively by GSI for long-term incubation studies.

3.3.3 Update of exposed lifetime predictions

There are presently (2011) four field failures of flexible polypropylene geomembranes and using unexposed archived samples from these sites their responses in laboratory UV Fluorescent devices per ASTM D7328 at 70°C are shown in Figure 5. From this information we deduce that the average correlation factor is approximately *1200 light hours* ~ *one-year in a hot climate.* This value will be used accordingly for other geomembranes.



(a) Two Sites in West Texas



(b) Two Sites in So. Calif.

Lab-to-Field Correlation Factors
(ASTM D7238 @ 70°C)

Method	Thickness (mm)	Field (yrs.)	Location	Lab (lt. hr.)	Factor (lt. hrs./1.0 yr.)
fPP-1	1.00	≃ 2	W. Texas	1800	900
fPP-R1	1.14	≃ 8	W. Texas	8200	1025
fPP-R2	0.91	≃ 2	So. Calif.	2500	1250
fPP-R3	0.91	≃ 8	So. Calif.	11200	1400
					1140*

*Use 1200 lt. hr. = 1.0 year in hot climates

Figure 5. Four field failures of fPP and fPP-R exposed geomembranes.

Exposure of a number of different types of geomembranes in laboratory UV Fluorescent devices per ASTM D7238 at 70°C has been ongoing for the six years (between 2005 and 2011) since this White Paper was first released. Included are the following geomembranes:

- Two black 1.0 mm (4.0 mil) unreinforced flexible polypropylene geomembranes formulated per GRI-GM18 Specification; see Figure 6a.
- Two black unreinforced polyethylene geomembranes, one 1.5 mm (60 mil) high density per GRI-GM13 Specification and the other 1.0 mm (40 mil) linear low density per GRI-GM17 Specification; see Figure 6b.
- One 1.0 (40 mil) black ethylene polypropylene diene terpolymer geomembrane per GRI-GM21 Specification; see Figure 6c.
- Two polyvinyl chloride geomembranes, one black 1.0 mm (40 mil) formulated in North America and the other grey 1.5 mm (60 mil) formulated in Europe; see Figure 6d.

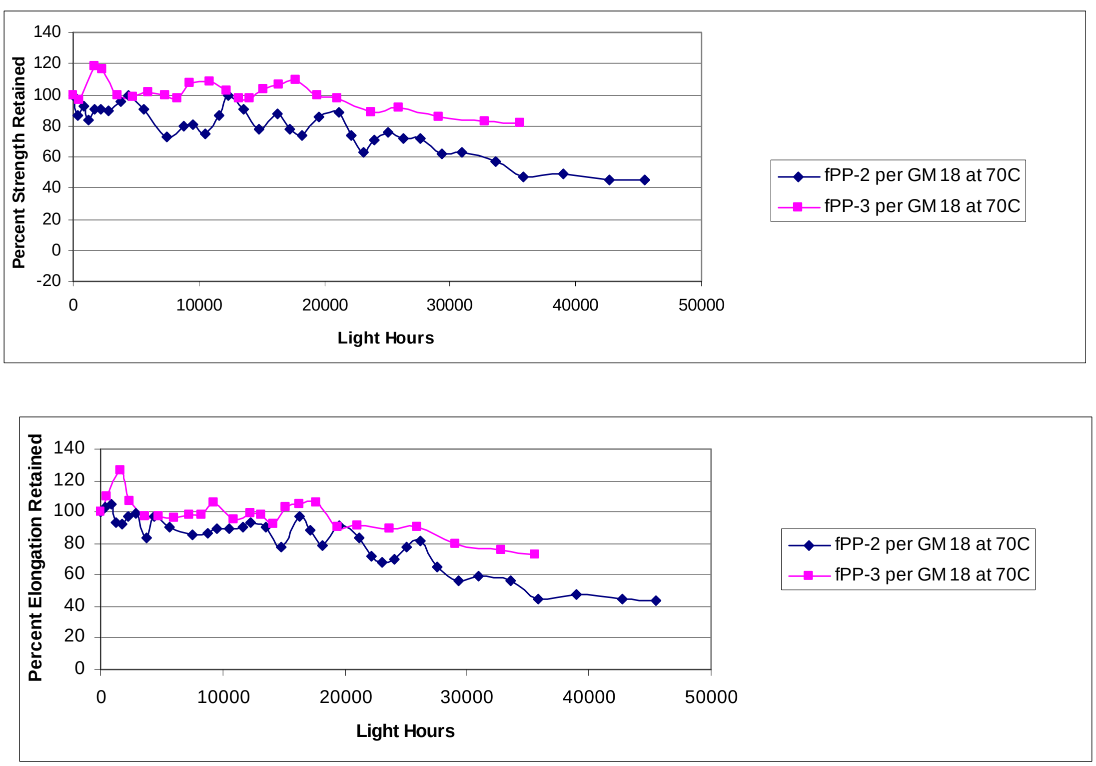
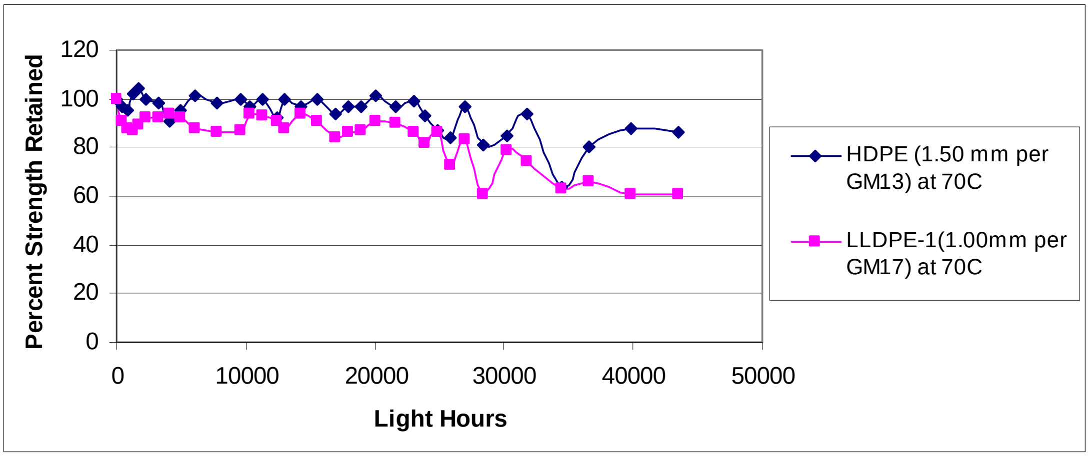


Figure 6a. Flexible polyethylene (fPP) geomembrane behavior.



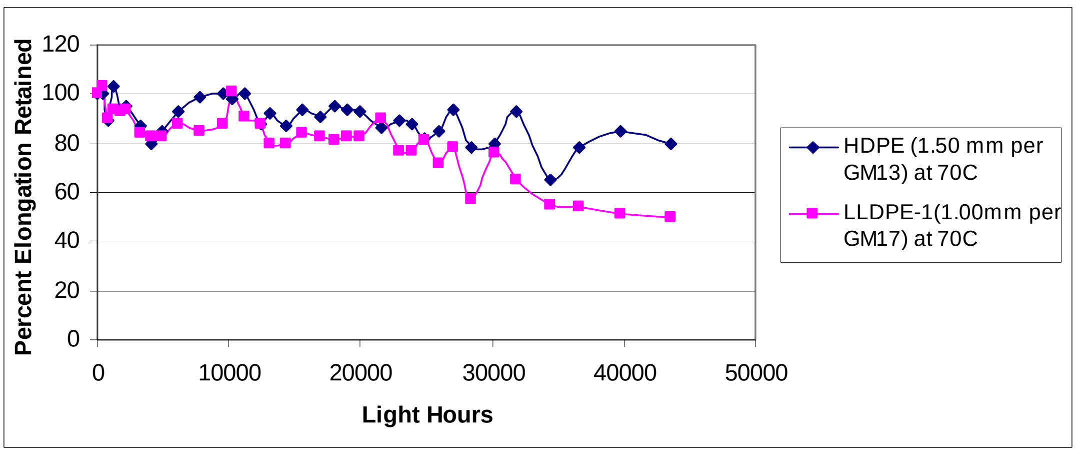
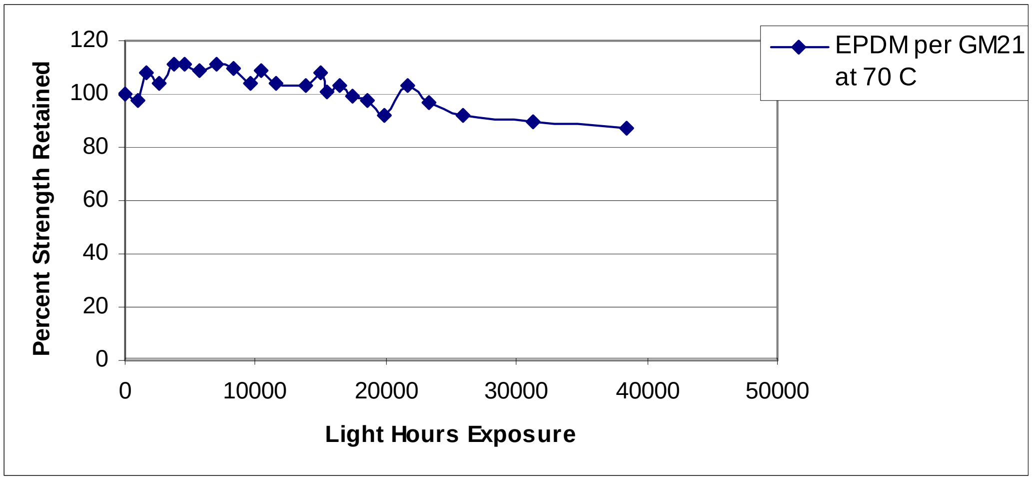


Figure 6b. Polyethylene (HDPE and LLDPE) geomembrane behavior.



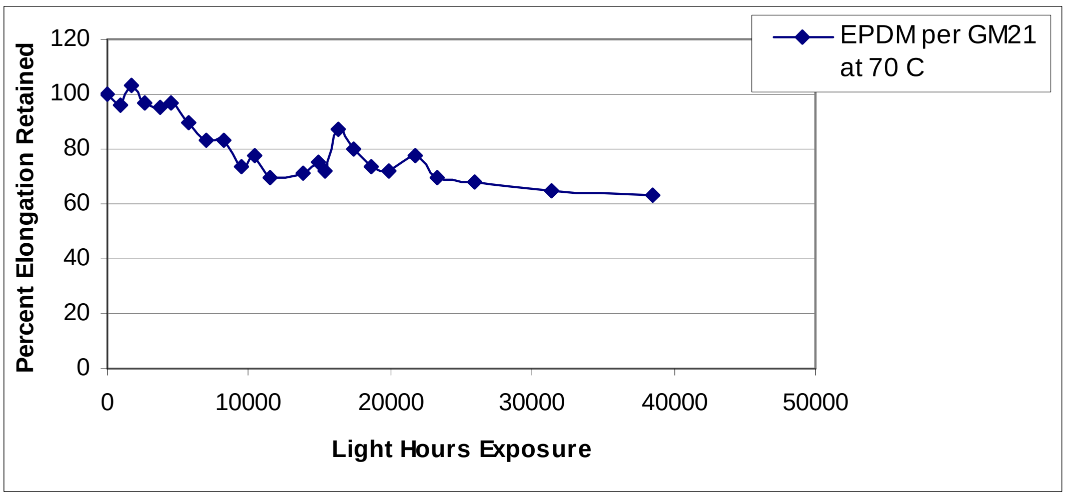


Figure 6c. Ethylene polypropylene diene terpolymer (EPDM) geomembrane.

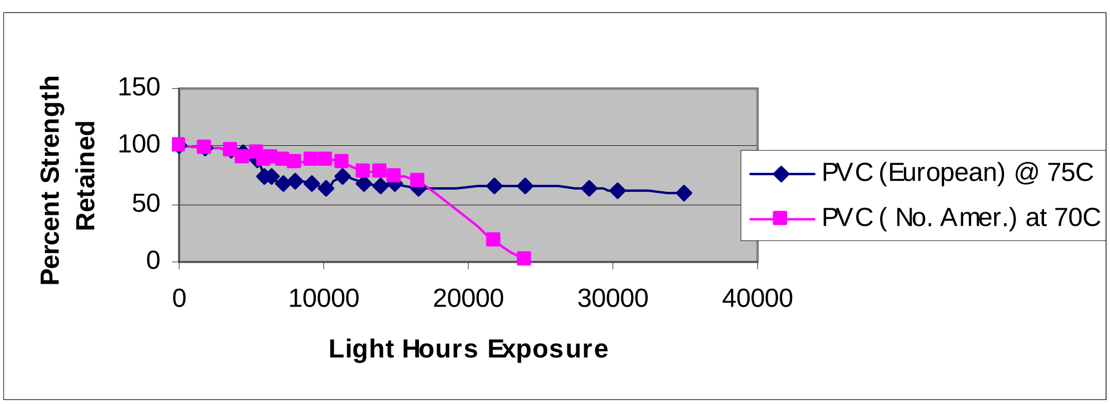


Figure 6d. Polyvinyl chloride (PVC) geomembranes.

From the response curves of the various geomembranes shown in Figure 6a-d, the 50% reduction value in strength or elongation (usually elongation) was taken as being the "halflife". This value is customarily used by the polymer industry as being the materials lifetime prediction value. We have done likewise to develop Table 6 which is our predicted values for the designated exposed geomembrane lifetimes to date.

Table 6 – Exposed lifetime prediction results of selected geomembranes to date

Type	Specification	Prediction Lifetime in a Dry and Arid Climate
HDPE	GRI-GM13	> 36 years (ongoing)
LLDPE	GRI-GM17	~ 36 years (halflife)
EPDM	GRI-GM21	> 27 years (ongoing)
fPP-2	GRI-GM18	~ 30 years (halflife)
fPP-3	GRI-GM18	> 27 years (ongoing)
PVC-N.A.	(see FGI)	~ 18 years (halflife)
PVC-Eur.	proprietary	> 32 years (ongoing)

4.0 Conclusions and Recommendations

This White Paper is bifurcated into two very different parts; covered (or buried) lifetime prediction of HDPE geomembranes and exposed (to the atmosphere) lifetime prediction of a number of geomembrane types. In the covered geomembrane study we chose the geomembrane type which has had the majority of usage, that being HDPE as typically used in waste containment applications. Invariably whether used in landfill liner or cover applications *the geomembrane is covered.* After ten-years of research Table 2 (repeated here) was developed which is the conclusion of the covered geomembrane research program. Here it is seen that HDPE decreases its predicted lifetime (as measured by its halflife) from 446-years at 20°C, to 69-years at 40°C. Other geomembrane types (LLDPE, fPP, EPDM and PVC) have had essentially no focused effort on their covered lifetime prediction of the type described herein. That said, all are candidates for additional research in this regard.

Table 2 - Lifetime prediction of HDPE (nonexposed) at various field temperatures

In Service Temperature (°C)	Stage "A" (years)			Stage "B" (years)	Stage "C" (years)	Total Prediction* (years)
	Standard OIT	High Press. OIT	Average OIT			
20	200	215	208	30	208	446
25	135	144	140	25	100	265
30	95	98	97	20	49	166
35	65	67	66	15	25	106
40	45	47	46	10	13	69

*Total = Stage A (average) + Stage B + Stage C

Exposed geomembrane lifetime was addressed from the perspective of field performance which is very unequivocal. Experience in Europe, mainly with relatively thick PVC containing high molecular weight plasticizers, has given 25-years of service and the geomembranes are still in use. Experience in the USA with exposed geomembranes on flat roofs, mainly with EPDM and CSPE, has given 20^+-years of service. The newest geomembrane type in such applications is fPP which currently carries similar warranties.

Rather than using the intricate laboratory setups of Figure 1 which are necessary for covered geomembranes, exposed geomembrane lifetime can be addressed by using accelerating laboratory weathering devices. Here it was shown that the UV fluorescent device (per ASTM D7238 settings) versus the Xenon Arc device (per ASTM D 4355) is equally if not slightly more intense in its degradation capabilities. As a result, all further incubation has been using the UV fluorescent devices per D7238 at 70°C.

Archived flexible polypropylene geomembranes at four field failure sites resulted in a correlation factor of 1200 light hours equaling one-year performance in a hot climate. Using this value on the incubation behavior of seven commonly used geomembranes has resulted in the following conclusions (recall Figure 6 and Table 6);

- HDPE geomembranes (per GRI-GM13) are predicted to have lifetimes greater than 36-years; testing is ongoing.
- LLDPE geomembranes (per GRI-GM17) are predicted to have lifetimes of approximately 36-years.
- EPDM geomembranes (per GRI-GM21) are predicted to have lifetimes of greater than 27-years; testing is ongoing.
- fPP geomembranes (per GRI-GM18) are predicted to have lifetimes of approximately 30-years.
- PVC geomembranes are very dependent on their plascitizer types and amounts, and probably thicknesses as well. The North American formulation has a lifetime of approximately 18-years, while the European formulation is still ongoing after 32-years.

Regarding continued and future recommendations with respect to lifetime prediction, GSI is currently providing the following:

(i) Continuing the exposed lifetime incubations of HDPE, EPDM and PVC (European) geomembranes at 70°C.

(ii) Beginning the exposed lifetime incubations of HDPE, LLDPE, fPP, EPDM and both PVC’s at 60°C and 80°C incubations.

(iii) With data from these three incubation temperatures (60, 70 and 80°C), time-temperature-superposition plots followed by Arrhenius modeling will eventually provide information such as Table 2 for covered geomembranes. This is our ultimate goal.

(iv) Parallel lifetime studies are ongoing at GSI for four types of geogrids and three types of turf reinforcement mats at 60, 70 and 80°C.

(v) GSI does not plan to duplicate the covered geomembrane study to other than the HDPE provided herein. In this regard, the time and expense that would be necessary is prohibitive.

(vi) The above said, GSI is always interested in field lifetime behavior of geomembranes (and other geosynthetics as well) whether covered or exposed.

Acknowledgements

The financial assistance of the U. S. Environmental Protection Agency for the covered HDPE lifetime study and the member organizations of the Geosynthetic Institute and its related institutes for research, information, education, accreditation and certification is sincerely appreciated. Their identification and contact member information is available on the Institute's web site at <<geosynthetic-institute.org>>.

References

Cazzuffi, D., "Long-Term Performance of Exposed Geomembranes on Dams in the Italian Alps," Proc. 6th Intl. Conf. on Geosynthetics, IFAI, 1998, pp. 1107-1114.

Chailan, J.-F., Boiteux, C., Chauchard, J., Pinel, B. and Seytre, G., "Effect of Thermal Degradation on the Viscoelastic and Dielectric Properties of Chlorosulfonated Polyethylene (CSPE) Compounds," Journal of Polymer Degradation and Stability, Vol. 48, 1995, pp. 61-65.

Comer, A. I., Hsuan, Y. G. and Konrath, L., "The Performance of Flexible Polypropylene Geomembranes in Covered and Exposed Environments," 6th International Conference on Geosynthetics, Atlanta, Georgia, USA, March, 1998, pp. 359-364.

Gedde, U. W., Viebke, J., Leijstrom, H. and Ifwarson, M., "Long-Term Properties of Hot-Water Polyolefin Pipes - A Review," Polymer Engineering and Science, Vol. 34, No. 24, 1994, pp. 1773-1787.

Giroud, J.-P. and Tisinger, L. G., "The Influence of Plasticizers on the Performance of PVC Geomembranes," PVC GRI-17 Conference, IFAI, Roseville, MN, 1994, pp. 169-196.

Hammon, M., Hsuan, G., Levin, S. B. and Mackey, R. E., "The Re-examination of a Nine-Year-Old PVC Geomembrane Used in a Top Cap Application," 31st Annual SWANA Conference, San Jose, CA, 1993, pp. 93-108.

Hsuan, Y. G. and Guan, Z., "Evaluation of the Oxidation Behavior of Polyethylene Geomembranes Using Oxidative Induction Time Tests," ASTM STP 1326, Riga and Patterson, Eds., ASTM, 1997, pp. 138-149.

Hsuan, Y. G. and Koerner, R. M., "Can Outdoor Degradation be Predicted by Laboratory Acceleration Weathering?," GFR, November, 1993, pp. 12-16.

Hsuan, Y. G. and Koerner, R. M., "Antioxidant Depletion Lifetime in High Density Polyethylene Geomembranes," Jour. Geotech. and Geoenviron. Engr., ASCE, Vol. 124, No. 6, 1998, pp. 532-541.

ICOLD (2010), "Geomembrane Sealing Systems for Dams: Design Principles and Return of Experience," Intl. Committee on Large Dams, Bulletin 135, Paris, France.

Koerner, G. R. and Koerner. R. M., "In-Situ Temperature Monitoring of Geomembranes," Proc. GRI-18 Conf. at GeoFrontiers, Austin, TX, 2005, 6 pgs.

Martin, J. R. and Gardner, R. J. (1983), "Use of Plastics in Corrosion Resistant Instrumentation," 1983 Plastics Seminar, NACE, October 24-27.

Miller, L. V., Koerner, R. M., Dewyea, J. and Mackey, R. E., "Evaluation of a 30 mil PVC Liner and Leachate Collection System," Proc. 29th Annual GRCDA/SWANA Conf., Cincinnati, OH, 1991.

Müeller, W. and Jakob, I., "Oxidative Resistance of High-Density Polyethylene Geomembranes," Jour. Polymer Degradation and Stability," Elsevier Publ. Co., No. 79, 2003, pp. 161-172.

Rapoport, N. Y. and Zaikov, G. E., "Kinetics and Mechanisms of the Oxidation of Stressed Polymer," Developments in Polymer Stabilization—4, G. Scott, Ed., Applied Science Publishers Ltd., London, U.K., 1986, pp. 207-258.

Sangam, H. P. and Rowe, R. K., "Effects of Exposure Conditions on the Depletion of Antioxidants from HDPE Geomembranes", Canadian Geotechnical Journal, Vol. 39, 2002, pp. 1221-1230.

Scuero, A., "The Use of Geocomposites for the Rehabilitation of Concrete Dams," Proc. 4th Intl. Conf. on Geosynthetics, The Hague, Balkema Publ. Co., 1990, pg. 474.

Scuero, A. M. and Vaschetti, G. L., "Geomembranes for Masonry and Concrete Dams: State-of-the-Art Report," Proc. Geosynthetics Applications, Design and Construction, M. B. deGroot, et al., Eds., A. A. Balkema, 1996, pp. 889-898.

Suits, L. D. and Hsuan, Y. G., "Assessing the Photo Degradation of Geosynthetics by Outdoor Exposure and Laboratory Weatherometers," Proc. GRI-15 Conference, Hot Topics in Geosynthetics II, GII Publ., Folsom, PA, 2001, pp. 267-279.

Wang, W. and Qu, B., "Photo and Thermo-Oxidative Degradation of Photocrosslinked Ethylene-Propylene-Diene Terpolymer," Journal of Polymer Degradation and Stability, Vol. 81, 2003, pp. 531-537.

EXHIBIT 15

SGI TESTING SERVICES
A GEORGIA LIMITED LIABILITY COMPANY

8 July 2010

Mr. Jose Urrutia
Closure Turf, LLC
3005 Breckinridge Blvd., Suite 240
Duluth, Georgia 3096

Subject: Evaluation of Drivability
Light Weight Construction Equipment on
Closure Turf™ System

Dear Mr. Urrutia,

DEFINITION OF CLOSURE TURF™ SYSTEM

As shown in Figure 1, the installed Closure Turf™ system from top to bottom consists of:

- A thin sand layer;
- Artificial grass with geotextile down;
- Agru 50-mil Super Gripnet with spike sides down; and
- Subgarde (foundation) soil.

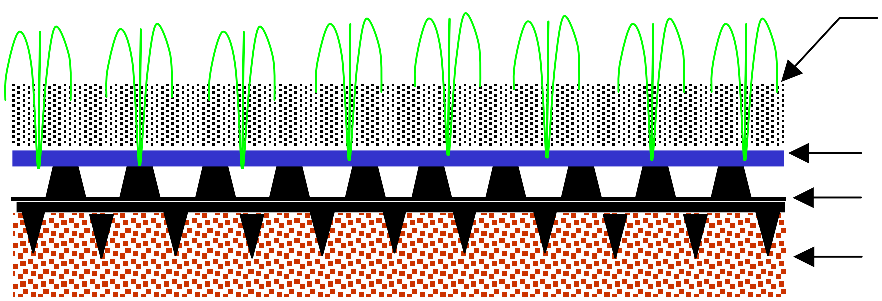


Figure 1. Cross-section of the Closure Turf system

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DEFINITION OF POST-CONSTRUCTION DRIVABILITY

Drivability of rubber-tired construction equipment (RTCE) on the Closure Turf™ system is a rather broad subject including: (i) stability - potential sliding (shear failure) within the Turf Closure system; (ii) bearing capacity of the subgrade soil; (iii) localized settlement after construction due to waste decomposing and compression under gravity force; and (iv) rut depth. The purpose of this report is to evaluate the stability within the Turf Closure system and bearing capacity of the subgrade soil.

STABILITY

As shown in Figure 2, when a RTCE moves at a constant speed on the Closure Turf system, its gravity load is transferred to the Closure Turf system through the tire-soil contact.

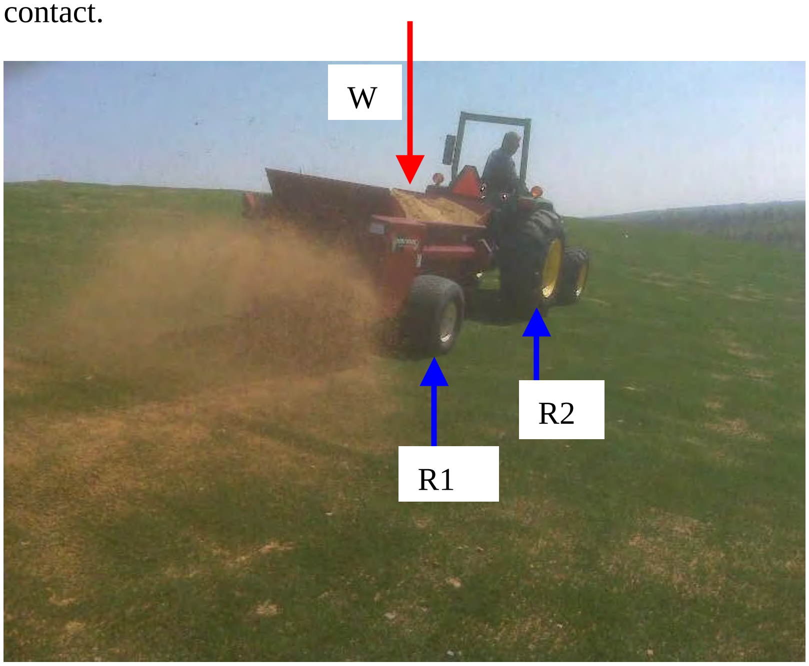


Figure 2. Rubber-tired construction equipment on the Closure Turf system.

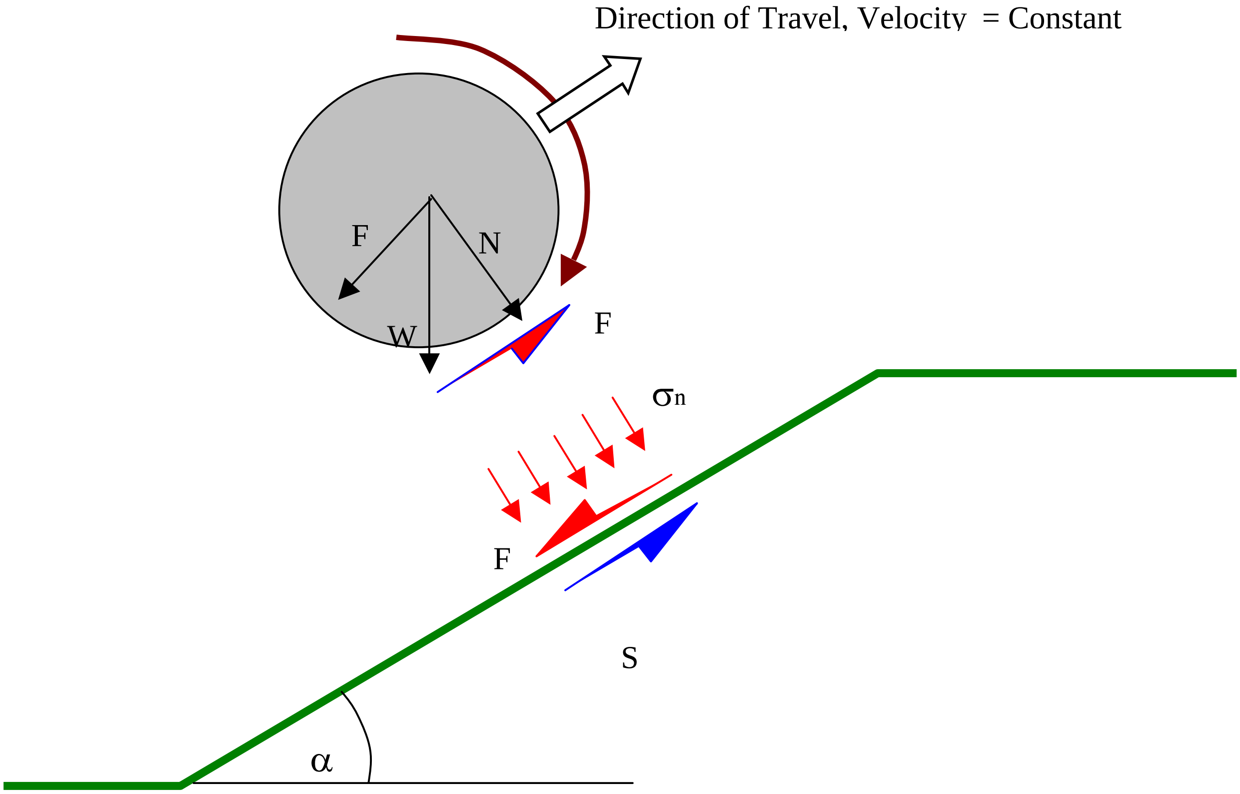


Figure 3. Tire-soil contact loading conditions on a slope. (NOTE: not to scale).

Assuming the gravity force of RTCE is evenly distributed to four tires, the contact normal stress at the tire-sand contact area as shown in Figure 3 can be estimated by the following equation:

$$\sigma_n = \frac{W \cos\alpha}{4A} \qquad (1)$$

where:

α = the slope angle;

σ_n = contact normal stress between the tire and sand;

W = total gravity force of equipment; and

A = contact area between a tire and sand layer.

Assuming: (i) the tire-soil contact area is approximately equivalent to a 10 inch diameter circular area and (ii) the total weight of a RTCE is 8000 lbs, then the contact normal stress in the unit of psi is:

$$\sigma_n = \frac{8000\cos\alpha}{4(3.14)(5^2)} = 25.5\cos\alpha \quad (2)$$

Equation (2) is also applicable to a level surface by setting $\alpha = 0$. This gives the maximum contact normal stress of 25.5 psi. It is noted that the tire-sand contact normal stress over a 10-inch diameter area is much higher than the overburden pressure of 1 inch thick cover sand. Therefore, it is necessary to evaluate the stability of the Closure Turf system in the tire-sand contact area under the high normal stress conditions. The shear strength parameters for this localized stability analysis should be determined from the interface direct shear tests at high normal stresses (2000 to 5000 psf). Based on the test results in Attachment 1, the peak friction angle and adhesion of the sand/artificial grass/Agru 50-mil Super Gripnet LLDPE geomemebrane system is 34 degree and 39 psf, respectively for the normal stress range of 2000 to 5000 psf. Under the drained conditions (i.e., no pore pressure induced by RTCE), neglecting the adhesion for the conservative reason, the safety factor (FS) against the localized shear failure within the tire-soil contact area is:

$$FS = \frac{A\sigma_n \tan\delta}{0.25(W)\sin\alpha} \quad (3)$$

where:

α = the slope angle;

σ_n = contact normal stress between the tire and sand;

δ = the peak friction angle of the Closure Turf system;

W = total gravity force of equipment; and

A = contact area between a tire and sand layer.

Substituting Equation (1) into (3), Equation (3) is reduced to:

$$FS = \frac{\tan \delta}{\tan \alpha} \quad (4)$$

For the given Closure Turf system, the peak friction angle is constant. It is obvious that FS decreases with increasing the slope angle. Based on the information provided by Closure Turf LLC, the maximum allowable slope angle is 18 degree (3:1 slope).

At $\alpha = 18.4$ degree,

$$FS = \frac{\tan 34}{\tan 18} = 2.0 \quad (5)$$

This indicates that there is sufficient shear resistance in the Closure Turf system against the localized shear failure within the tire-soil area. It is not expected the localized internal shear failure to occur within the tire-soil contact area of Closure Turf system when it subjected to the gravity force from a typical lightweight RTCE traveling at a constant velocity.

BEARING CAPACITY

For a given RTCE, W and A are constant, therefore the maximum contact normal stress occurs when the RTCE travels on the level surface (Equation 1). The contact normal stress is transferred to the subgade soil as shown in Figure 4.

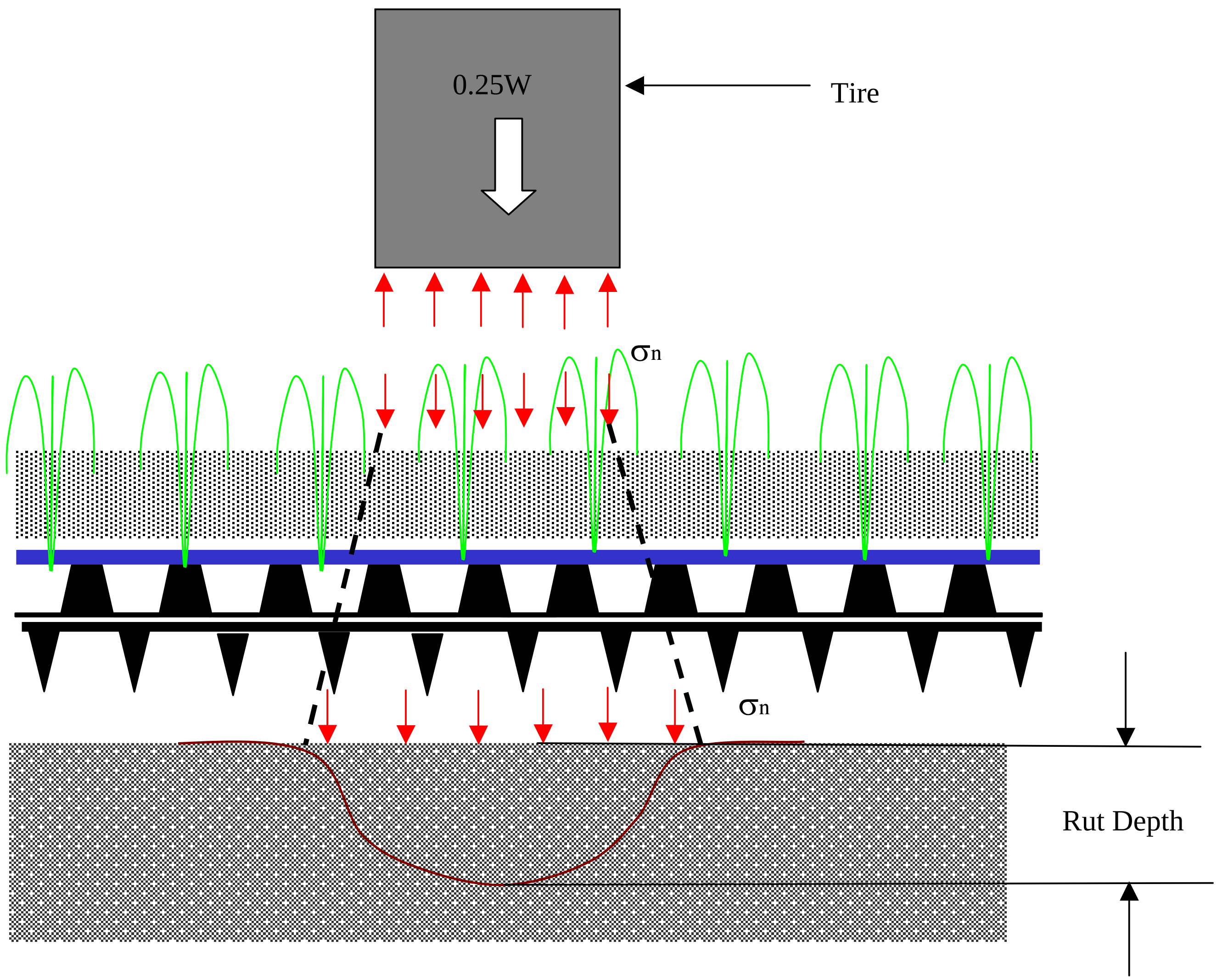


Figure 4. Normal stress acting on top of the subgrade (foundation) soil

Based on soil mechanics, the contact load (0.25W) distributes to a larger area as depth increases (depth starting from the top surface of the cover sand). However, due to the fact that the cover sand layer is only 1 inch thick, and the artificial grass and geomembrane are flexible, the load spreading angle (factor) is insignificant. The normal stress transferred to the top of subgrade soil is considered the same as the tire-sand contact stress for the conservative reason.

As shown previously (Equation 2), assuming (i) the tire-soil contact area is approximately a 10 inch diameter circular area and (ii) the total weight of a RTCE is 8000 lbs, then the maximum contact normal stress is:

$$\sigma_n = \frac{8000\cos\alpha}{4(3.14)(5^2)} = 25.5\,psi \qquad (6)$$

Under the action of tire-sand contact normal stress over the contact area (10 in diameter), there are two major concerns:

- Excessive rut depth, which is not defined for the Closure Turf system at the present time. Generally speaking, the subgrade soil settles and rut forms when it is subjected a normal stress. As number of vehicle passes increases, the rut depth increases. Eventually the surface may reach such a condition that driving is difficult if the accumulated pass is larger than some critical number. Therefore, for the given type of equipment (W and A are fixed), one way to reduce rut depth is to limit the number of passes. This may be achieved by not driving over the same area when a significant rut depth is already developed. The other way is to compact subgrade soil to high density to improve the stiffness for the subgrade soil.

- Bearing capacity failure because the contact normal stress is greater than the bearing capacity of the subgrade soil.

In the case of soft subgrade soil (worst case), the bearing capacity is estimated by the following equation:

$$q_u = c_u N_C \qquad (7)$$

where:

c_u = undrained shear strength of soft subgrade soil

N_c = bearing capacity factor (6.2 for a circular loading area)

$$q_u = 6.2c_u \qquad (8)$$

For the soft subgrade soil, the safety factor against bearing capacity failure is:

$$FS = \frac{6.2c_u}{\sigma_n} \qquad (9)$$

Typically, the acceptable bearing capacity safety factor is 2.0. The required undrained shear strength for the subgrade soil is,

$$c_u \geq \frac{2(25.5)}{6.2} = 8.2\,psi \qquad (10)$$

The value of c_u can be estimated from the widely used CBR value for soft subgrade soil with CBR < 5 using the following equation (Giroud and Noiray 1981):

$$c_u = 4.3CBR \qquad (11)$$

Substituting Equation 11 into 10 gives the following equation:

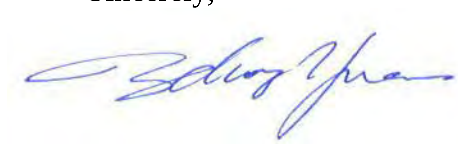
$$CBR \geq 1.9 \qquad (12)$$

Therefore, under the action of the gravity force from a typical RTCE (W = 8000 lbs, A = 79 square inch), the required minimum CBR value for the subgrade is 2. In reality, a well-compacted subgarde soil for the Closure Turf system should have a CBR value significantly higher than 2. It is expected that a well-compacted subgarde soil layer (SM or SC, typically used as subgarde soil for the landfill cover system) should have sufficient bearing capacity to support the lightweight RTCE.

CLOSURE

SGI appreciates the opportunity to provide technical services to Closure Turf, LLC. Should you have any questions regarding the attached document(s), or if you require additional information, please do not hesitate to contact the undersigned.

Sincerely,



Zehong Yuan, Ph.D., P.E.
Laboratory Manager

REFERENCES

Giroud, J.P., and Noiray, L. (1981) "Geotextile-reinforced unpaved road design." Journal of Geotechnical Engineering 107(9), 1233-1254.

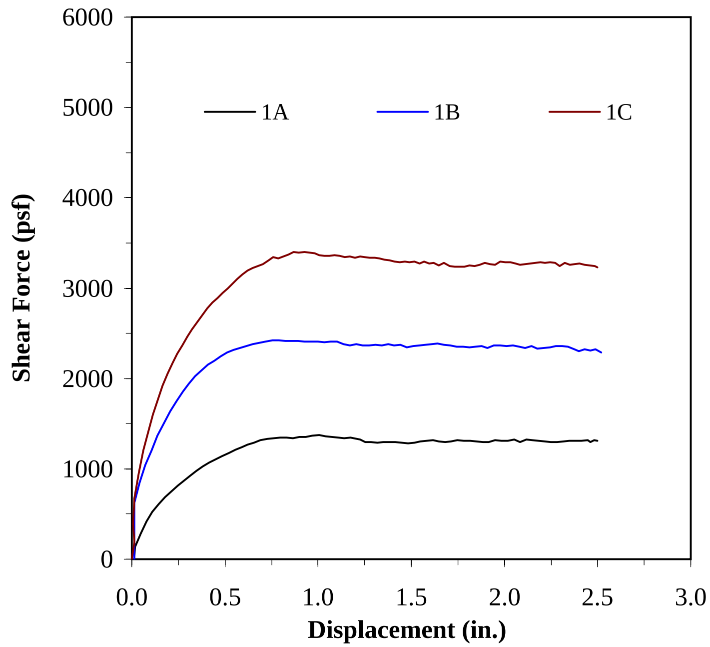
NOTES:
(1) Unless otherwise noted in the test results the sample(s)/specimen(s) were prepared in accordance with the applicable test standards or generally accepted sampling procedures.
(2) Contaminated/chemical samples and all related laboratory generated waste (i.e., test liquids, PPE, absorbents, etc.) will be returned to the client or designated representative(s), at the client's cost, within 60 days following the completion of the testing program, unless special arrangements for proper disposal are made with SGI.
(3) Materials that are not contaminated will be discarded after test specimens and archived specimens are obtained. Archived specimens will be discarded 30 days after the completion of the testing program, unless long-term storage arrangements are specifically made with SGI.
(4) The reported results apply only to the materials and test conditions used in the laboratory testing program. The results do not necessarily apply to other materials or test conditions. The test results should not be used in engineering analysis unless the test conditions model the anticipated field conditions. The testing was performed in accordance with general engineering testing standards and requirements. The reported results are submitted for the exclusive use of the client to whom they are addressed.

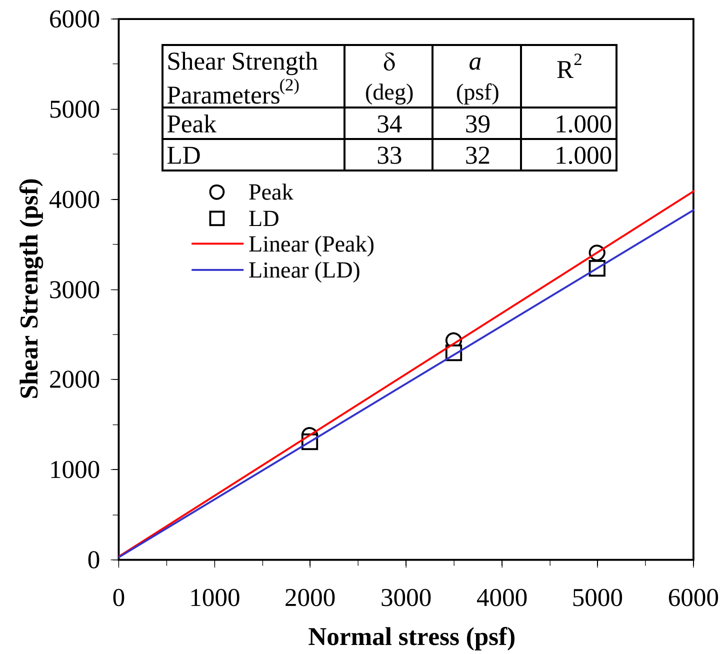
ATTACHMENT 1

INTERFACE DIRECT SHEAR TEST RESULTS

CLOSURETURF LLC -LANDFILL COVER SYSTEM
INTERFACE DIRECT SHEAR TESTING (ASTM D 5321)

Upper Shear Box: Concrete sand nominally compacted
Artificial grass with grass side (green yarns) up/
Agru 50 mil LLDPE Super Gripnet geomembrane with studs side up/
Lower Shear Box: Concrete sand





Test No.	Shear Box Size (in. x in.)	Normal Stress (psf)	Shear Rate (in./min)	Soaking Stress (psf)	Soaking Time (hour)	Consolidation Stress (psf)	Consolidation Time (hour)	Lower Soil γ_d (pcf)	Lower Soil ω_i (%)	Lower Soil ω_f (%)	Upper Soil γ_d (pcf)	Upper Soil ω_i (%)	Upper Soil ω_f (%)	GCL ω_i (%)	GCL ω_f (%)	Shear Strengths τ_P (psf)	Shear Strengths τ_{LD} (psf)	Failure Mode
1A	12 x 12	2000	0.04	10	24	-	-	-	-	-	-	-	-	-	-	1376	1308	(1)
1B	12 x 12	3500	0.04	20	24	-	-	-	-	-	-	-	-	-	-	2425	2291	(1)
1C	12 x 12	5000	0.04	50	24	-	-	-	-	-	-	-	-	-	-	3400	3233	(1)

NOTES:
(1) Sliding (i.e., shear failure) occurred at the interface between the cover (upper) sand and artificial grass.
(2) The reported total-stress parameters of friction angle and adhesion were determined from a best-fit line drawn through the test data. Caution should be exercised in using these strength parameters for applications involving normal stresses outside the range of the stresses covered by the test series. The large-displacement (LD) shear strength was calculated using the shear force measured at the end of the test.

DATE OF TEST:	6/21/2010
FIGURE NO.	C-1
PROJECT NO.	SGI10007
DOCUMENT NO.	
FILE NO.	

SGI TESTING SERVICES, LLC

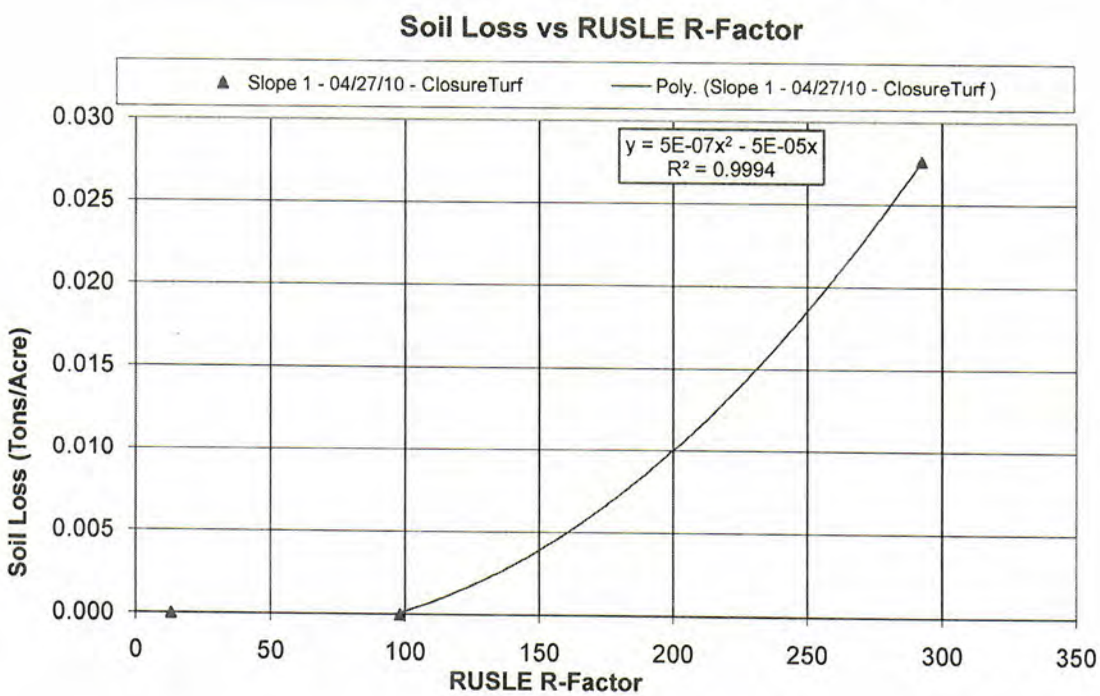
EXHIBIT 16

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

Project: ASTM D 6459
Client: RPH
Test Date: 4/26/2010
Rainfall Rates: 2,4,6 in/hr (target); 20 minutes at each intensity (60 min. total)
Bed Size & Slope: 8-ft wide x 40-ft long; 3H:1V
Sand Ballast Layer, lbs: 1130 (approximately 1/2-inch thick, hand spread)

Plot	Intensity (in/hr)	Runoff (gallons)	Cumm. R-Factor	Soil Loss (lbs/slope)	Sediment Yield (tons/acre)	% of Ballast in Runoff/Seepage
ClosureTurf	2.36	93	13.13	0.00	0.00	0.04%
	4.65	258	97.99	0.00	0.00	
	6.57	360	292.43	0.41	0.03	

Time (min)	Cumm. Rainfall (in)	Cumm. Runoff (in)	Peak Runoff (cfs)	CN[1]	Rational "C"[2]
20	0.79	0.46	0.013	96.2	0.74
40	2.34	1.76	0.026	94.5	0.76
60	4.53	3.56	0.038	91.3	0.78

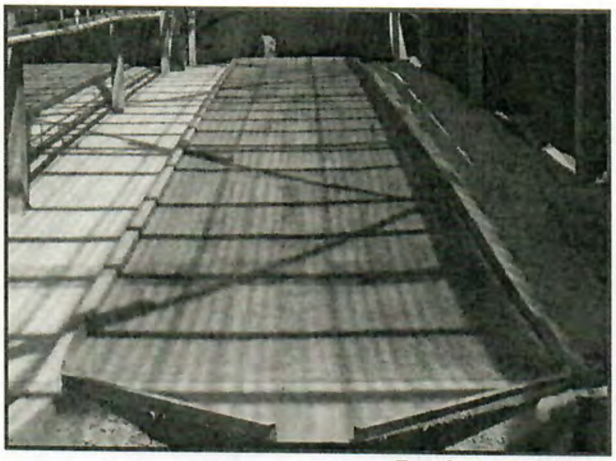


1. The effective runoff curve number was determined by solving for S in the equation Q = [(P-0.2S)2/(P+0.8S)] where Q is the depth of runoff (in) and P is the rainfall depth (in). Then, CN = 1000/(S+10).

2. The rational "C" coefficient was determined by solving for C in Q = C I A where Q is the peak discharge rate (cfs), I is the peak rainfall intensity (in/hr) and A is the drainage area (acre).

Note: The testing is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose

CJS 5/5/10
Quality Review / Date




Test Slope Prepared and Liner Installed


Synthetic Turf Deployed and Sand Ballast Layer Hand-Applied


2, 4, and 6 in/hr Rainfall Applied in Succession and Substantial In-Plane Drainage Observed


Bottle Grab Samples and Flow Rate Measurements Taken During Testing


Only Small Amounts of Sand Migrated Within the Drainage Layer and Little Sand Movement Was Observed On Surface


Typical Unprotected Slope Erosion from Testing Protocol (2 in/hr on left; 6 in/hr on right)

APPENDIX - DATA

DDRF Rainfall Testing

Slope #: 1 | **Target Rain:** 2 in/hr

Date: 4/26/2010 | Start Rain: 12:25 PM | End Rain: 12:45 PM

Sampling interval: 0:03 | End Runoff: 12:47 PM

Rain Time (min): 20.00 | Test Time (min): 22.00

Product: ClosureTurf | Descr:. Membrane and Synthetic Turf Capping System

Lot #: n/a | Anchors: Sand | Anchorage: 1/2-inch Thick

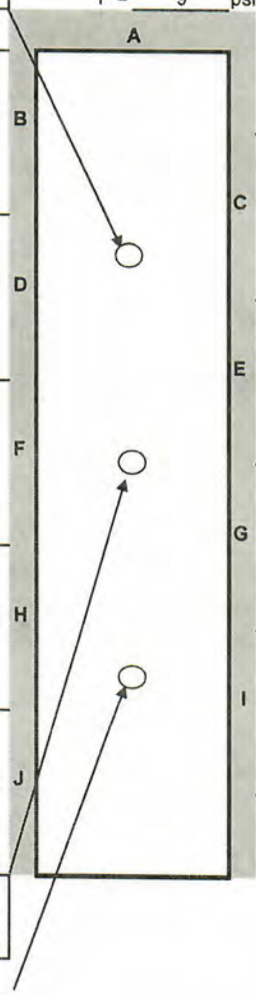
TOP OF SLOPE

(circle "x" for open valves) **Set valves to 9 psi.**

w_{c1} = 17.7%

d = 23 mm
i = 2.72 in/hr

x x x X
P = 9 psi



Valve	Left valves	P (psi)	Right valves
A	x x x X (top)	9	
B	X x x x	9	
C		9	x X x x
D	x X x x	9	
E		9	x X x x
F	x X x x	9	
G		9	x x X x
H	x x X x	9	
I		9	x x X
J	x x X X	9	

d = 18 mm
i = 2.13 in/hr
w_{c2} = 17.4%

d = 19 mm
i = 2.24 in/hr
w_{c3} = 18.6%

Temp. 78 deg
Hum. 78 %

Average Depth: 20.00 mm
Avg Rainfall Intensity: 2.36 in/hr

Notes:
0 mph breeze.
Approx 92 gal collected.

Sediment Concentration Grab Samples Followed by Runoff Rate Measurements

#	Time	
1	12:28	
2	12:31	
3	12:34	
4	12:37	
5	12:40	
6	12:43	
7		
8		
9		
10		
11		
12		
13		
14		
15		
12		
13		
14		
15		

Runoff Rate Measurements

#	Time	Time to Collect 1 Gallon, Seconds
1	2	180
2	6	31
3	10	15
4	14	10
5	18	10
6	20	9
7		
8		
9		
10		
11		
12		
13		
14		
15		
12		
13		
14		
15		

DDRF Rainfall Testing

Slope #: 1 | **Target Rain: 4 in/hr**

Date: 4/26/2010 | Start Rain: 12:53 PM | End Rain: 1:13 PM

Sampling interval: 0:02 | End Runoff: 1:17 PM

Rain Time (min): 20.00 | Test Time (min): 24.00

Product: ClosureTurf | Descr:. Membrane and Synthetic Turf Capping System

Lot #: n/a | Anchors: Sand | Anchorage: 1/2-inch Thick

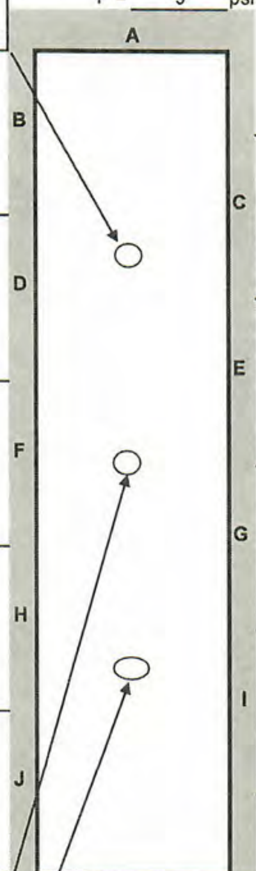
TOP OF SLOPE | **Set valves to 9 psi.**

X X x x

P = 9 psi

w_{c1} = 17.7%

d = 42 mm
i = 4.96 in/hr



Valve	P (psi)
A	9
B	9
C	9
D	9
E	9
F	9
G	9
H	9
I	9
J	9

d = 39 mm
i = 4.61 in/hr

w_{c2} = 17.4%

d = 37 mm
i = 4.37 in/hr

w_{c3} = 18.6%

Temp. 77 deg
Hum. 86 %

Average Depth: **39.33** **mm**

Avg Rainfall Intensity: **4.65** **in/hr**

Sediment Concentration Grab Samples Followed by Runoff Rate Measurements

#	Time	
1	12:55	
2	12:57	
3	12:59	
4	13:01	
5	13:03	
6	13:05	
7	13:07	
8	13:09	
9	13:11	
10	13:13	
11		
12		
13		
14		
15		
12		
13		
14		
15		

Runoff Rate Measurements

#	Time	Time to Collect 1 Gallon, **Seconds**
1	2	8
2	4	6
3	6	6
4	8	6
5	10	6
6	12	6
7	14	5
8	16	5
9	18	5
10	20	5
11		
12		
13		
14		
15		
12		
13		
14		
15		

Notes:
0 mph breeze.
Approx 260 gal collected.

DDRF Rainfall Testing

Slope #: 1 | **Target Rain: 6 in/hr**

Date:	4/26/2010	Start Rain:	12:53 PM	End Rain:	1:13 PM
		Sampling interval:	0:02	End Runoff:	1:17 PM
		Rain Time (min):	20.00	Test Time (min):	24.00
Product:	ClosureTurf	Descr:.	Membrane and Synthetic Turf Capping System		
Lot #:	n/a	Anchors:	Sand	Anchorage:	1/2-inch Thick

TOP OF SLOPE

(circle "x" for open valves)

Set valves to 9 psi.

w_{c1} = 17.7%

d = 57 mm

i = 6.73 in/hr

x X X X

A: P = 9 psi

Valve	P (psi)
B	9
C	9
D	9
E	9
F	9
G	9
H	9
I	9
J	9

d = 58 mm

i = 6.85 in/hr

w_{c2} = 17.4%

d = 52 mm

i = 6.14 in/hr

w_{c3} = 18.6%

Temp. 69 deg

Hum. 88 %

Average Depth: **55.67** **mm**

Avg Rainfall Intensity: **6.57** **in/hr**

Notes:
0 mph breeze.
Approx 360 gal collected.

Sediment Concentration Grab Samples Followed by Runoff Rate Measurements

#	Time	
1	12:55	
2	12:57	
3	12:59	
4	13:01	
5	13:03	
6	13:05	
7	13:07	
8	13:09	
9	13:11	
10	13:13	
11		
12		
13		
14		
15		
12		
13		
14		
15		

Runoff Rate Measurements

#	Time	Time to Collect 1 Gallon, Seconds
1	2	4
2	4	4
3	6	4
4	8	4
5	10	4
6	12	4
7	14	4
8	16	4
9	18	4
10	20	4
11		
12		
13		
14		
15		
12		
13		
14		
15		

0-Jan-00

Slope #1

Sample Number	Test Time, minutes	Time per Gallon, sec	Interval Time, min	Total Time, min	Collection Mid-Time, min	Runoff Rate, gal/min	Associated Runoff, gal	Cumulative Runoff, gal	
2.36 in/hr									
2	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	
2-1	2.00	180	5.00	5.00	3.50	0.33	1.67	1.67	
2-2	6.00	31	1.52	6.52	6.26	1.94	2.94	4.60	
2-3	10.00	15	3.73	10.25	10.13	4.00	14.93	19.54	
2-4	14.00	10	3.92	14.17	28.17	6.00	23.50	43.04	
2-5	18.00	10	4.00	18.17	36.17	6.00	24.00	67.04	
2-6	20.00	9	1.98	20.15	40.15	6.67	13.22	80.26	
2-end	22.00		1.85	22.00			12.33	**92.59**	**Total Collected Runoff (approx)**
4.65 in/hr									
4	0	0	0.00	0.00	0.00	0.00	0.00	0.00	
4-1	2	8	2.13	2.13	2.07	7.50	16.00	16.00	
4-2	4	6	1.97	4.10	4.05	10.00	19.67	35.67	
4-3	6	6	2.00	6.10	6.05	10.00	20.00	55.67	
4-4	8	6	2.00	8.10	8.05	10.00	20.00	75.67	
4-5	10	6	2.00	10.10	10.05	10.00	20.00	95.67	
4-6	12	6	2.00	12.10	12.05	10.00	20.00	115.67	
4-7	14	5	1.98	14.08	14.04	12.00	23.80	139.47	
4-8	16	5	2.00	16.08	16.04	12.00	24.00	163.47	
4-9	18	5	2.00	18.08	18.04	12.00	24.00	187.47	
4-10	20	5	2.00	20.08	20.04	12.00	24.00	211.47	
4-end	24.00		3.92	24.00			47.00	**258.47**	**Total Collected Runoff (approx)**
5.90 in/hr									
6	0	0	0.00	0.00	0.00	0.00	0.00	0.00	
6-1	2	4	2.07	2.07	2.03	15.00	31.00	31.00	
6-2	4	4	2.00	4.07	4.03	15.00	30.00	61.00	
6-3	6	4	2.00	6.07	6.03	15.00	30.00	91.00	
6-4	8	4	2.00	8.07	8.03	15.00	30.00	121.00	
6-5	10	4	2.00	10.07	10.03	15.00	30.00	151.00	
6-6	12	4	2.00	12.07	12.03	15.00	30.00	181.00	
6-7	14	4	2.00	14.07	14.03	15.00	30.00	211.00	
6-8	16	4	2.00	16.07	16.03	15.00	30.00	241.00	
6-9	18	4	2.00	18.07	18.03	15.00	30.00	271.00	
6-10	20	4	2.00	20.07	20.03	15.00	30.00	301.00	
6-end	24.00		3.93	24.00			59.00	**360.00**	**Total Collected Runoff (approx)**

Slope #1 - Sediment Concentration

	Sample Number	Test Time, minutes	Total Weight, g	Decanted Weight, g	Dry Weight, g	Bottle Weight, g	Dry Sediment Weight, mg	Total Collected Water Wt., g	Total Collected Volume of Water, l	Sediment Concentration, mg/l	Runoff Sampling Time	Time to Collect 1 gal	Associated Runoff, gal	Associated Sediment Conc, mg/l	Associated Solids Loss, lbs
#DIV/0! in/hr	avg														
0-Jan-00	2-1	3.00	300.51	32.92	32.92	32.92	0.00	267.59	0.27	0.00	2.00	180	1.67	0.00	0.00
	2-2	6.00	310.76	32.92	32.92	32.92	0.00	277.84	0.28	0.00	6.00	31	2.94	0.00	0.00
	2-3	9.00	305.13	32.92	32.92	32.92	0.00	272.21	0.27	0.00	10.00	15	14.93	0.00	0.00
	2-4	12.00	311.56	32.92	32.92	32.92	0.00	278.64	0.28	0.00	14.00	10	23.50	0.00	0.00
	2-5	15.00	298.63	32.92	32.92	32.92	0.00	265.71	0.27	0.00	18.00	10	24.00	0.00	0.00
	2-6	18.00	304.77	32.92	32.92	32.92	0.00	271.85	0.27	0.00	20.00	9	13.22	0.00	0.00
4.24 in/hr	avg								AVG =	**0.00**	22.00	0	12.33	0.00	0.00
													Total Solids Lost:		**0.00**
11/5/2009	4-1	2.00	311.17	32.92	32.92	32.92	0.00	278.25	0.28	0.00	2.00	8	16.00	0.00	0.00
	4-2	4.00	308.34	32.92	32.92	32.92	0.00	275.42	0.28	0.00	4.00	6	19.67	0.00	0.00
	4-3	6.00	290.56	32.92	32.92	32.92	0.00	257.64	0.26	0.00	6.00	6	20.00	0.00	0.00
	4-4	8.00	313.40	32.92	32.92	32.92	0.00	280.48	0.28	0.00	8.00	6	20.00	0.00	0.00
	4-5	10.00	313.35	32.92	32.92	32.92	0.00	280.43	0.28	0.00	10.00	6	20.00	0.00	0.00
	4-6	12.00	310.89	32.92	32.92	32.92	0.00	277.97	0.28	0.00	12.00	6	20.00	0.00	0.00
	4-7	14.00	314.63	32.92	32.92	32.92	0.00	281.71	0.28	0.00	14.00	5	23.80	0.00	0.00
	4-8	16.00	317.22	32.92	32.92	32.92	0.00	284.30	0.28	0.00	16.00	5	24.00	0.00	0.00
	4-9	18.00	315.58	32.92	32.92	32.92	0.00	282.66	0.28	0.00	18.00	5	24.00	0.00	0.00
	4-10	20.00	313.87	32.92	32.92	32.92	0.00	280.95	0.28	0.00	20.00	5	24.00	0.00	0.00
5.90 in/hr	avg								AVG =	**0.00**	24.00	0	47.00	0.00	0.00
													Total Solids Lost:		**0.00**
6/11/2009	6-1	2.00	317.68	32.92	32.92	32.92	0.00	284.76	0.28	0.00	2.00	4.00	31.00	0.00	0.00
	6-2	4.00	315.42	32.92	32.92	32.92	0.00	282.50	0.28	0.00	4.00	4.00	30.00	0.00	0.00
	6-3	6.00	314.68	32.92	32.92	32.92	0.00	281.76	0.28	0.00	6.00	4.00	30.00	0.00	0.00
	6-4	8.00	312.89	32.92	32.92	32.92	0.00	279.97	0.28	0.00	8.00	4.00	30.00	0.00	0.00
	6-5	10.00	313.42	32.92	32.92	32.92	0.00	280.50	0.28	0.00	10.00	4.00	30.00	0.00	0.00
	6-6	12.00	309.16	32.92	32.92	32.92	0.00	276.24	0.28	0.00	12.00	4.00	30.00	0.00	0.00
	6-7	14.00	313.41	32.92	32.92	32.92	0.00	280.49	0.28	0.00	14.00	4.00	30.00	0.00	0.00
	6-8	16.00	315.77	32.92	32.92	32.92	0.00	282.85	0.28	0.00	16.00	4.00	30.00	0.00	0.00
	6-9	18.00	309.69	32.92	32.92	32.92	0.00	276.77	0.28	0.00	18.00	4.00	30.00	0.00	0.00
	6-10	20.00	310.70	32.92	32.92	32.92	0.00	277.78	0.28	0.00	20.00	4.00	30.00	0.00	0.00
									AVG =	**0.00**	24.00	0.00	59.00	0.00	0.00
													Total Solids Lost:		**0.00**

SLOPE #1 - Sediment Weights

Total Dry Sediments: 0.00

2 in/hr	Collected	Typ. TSS in Decanted Collected Runoff, lb/gal
Wt. Of pan + wet soil, g	0	
Wt. Of pan + dry soil, g	0	
Wt. Of pan, g	0	
Wt. Of dry soil, g	0	0
Wt. Of water, g		Collected Runoff, gal
Water Content, w%		
Total Wet Sediments,g		
% dry solids		92.6
Dry Collected Sediments, g	0.00	0.00

Total Dry Sediments: 0.00

4 in/hr	Collected	Typ. TSS in Decanted Collected Runoff, lb/gal
Wt. Of pan + wet soil, g	0	
Wt. Of pan + dry soil, g	0	
Wt. Of pan, g	0	
Wt. Of dry soil, g	0	0
Wt. Of water, g		Collected Runoff, gal
Water Content, w%		
Total Wet Sediments, g		
% dry solids		258.5
Dry Collected Sediments, g	0.00	0.00

Total Dry Sediments, lbs: 0.41

6 in/hr	Collected	Typ. TSS in Decanted Collected Runoff, lb/gal
Wt. Of pan + wet soil, g	402.35	
Wt. Of pan + dry soil, g	400.76	
Wt. Of pan, g	216.31	
Wt. Of dry soil, g	184.45	0
Wt. Of water, g	1.59	Collected Runoff, gal
Water Content, w%	0.9	
Total Wet Sediments, g		
% dry solids		360.0
Dry Collected Sediments, g	184.45	0.00

EXHIBIT 17

Summary of Benefits of ClosureTurf®

Superior Performance When Compared to EPA Subtitle D Final Closure Design

Watershed Geosynthetics, LLC has prepared this document to define the range of benefits of using ClosureTurf® as a final cover system in EPA Subtitle D applications. ClosureTurf offers several substantial performance benefits and environmental benefits over traditional and regulatory prescriptive designs for final closure of landfills and/or impoundments.

ClosureTurf provides significant technical advantages as a final closure system in comparison with the traditional EPA Subtitle D soil and vegetative cover treatment. Those benefits have been validated through extensive documented laboratory testing conducted at leading independent and existing operating facilities.

ClosureTurf is a more environmentally sound application when compared to traditional soil and vegetative covers. Some of these include improved water quality, land preservation and significant carbon footprint reduction. These environmental advantages are both quantifiable and effective.

As presented below, the **regulatory criteria for evaluating an alternative cover system is to control infiltration and erosion.** Based on several years of real world experience on over 40 million square feet installed, and extensive university and ASTM lab evaluations, the ClosureTurf system has shown to have a **leakage rate over 40 times less** than subtitle D prescriptive cover and an **erosion loss of over 100 times less** than subtitle D prescriptive cover.

<u>ClosureTurf Benefits</u>

1) Regulatory Compliance

ClosureTurf is a three-component system comprised of a structural geomembrane, engineered synthetic turf, and a specified infill that meets and/or exceeds all of the requirements set forth by the EPA in “Subtitle D”. EPA Subtitle D rules specifically state: *“An alternative cover design may be used as long as it provides equivalent protection against infiltration and erosion.”* ClosureTurf significantly outperforms traditional Subtitle D closures based on these criteria, with the added benefit of performance well beyond the regulatory post-closure period.

2) Safety and Community Impact Reduction

The system eliminates approximately 350 truck trips, per acre, from local roadways that would otherwise be used transporting soil to and from a borrow site. This reduction in size, number and duration of equipment means an overall increase in safety on both the project site and ingress and egress, while reducing dust, mud on roads and noise impacts to the surrounding community. Most traditional closures also require destruction of land in the community for project soil demands, resulting in secondary impacts and loss of future land use.

3) Sustainability

ClosureTurf reduces the carbon footprint of a closure by approximately 80% when compared with traditional soil/vegetative covers. In addition, ClosureTurf provides an ideal foundation for future beneficial uses.

Traditional post-closure plans identify the post-closure use simply as dead space. Note that ClosureTurf has been used for post-closure uses such photovoltaic solar panel arrays, allowing what is typically written off as "dead space" to be utilized as a renewable energy site. This feature is inherent with the ClosureTurf system and requires no immediate preparation or planning to accommodate possible future solar use.

4) Water Quality

The engineered synthetic turf and specified infill effectively filters surface water, providing clean runoff with very low turbidity. In addition, the system significantly reduces sediment loading to surrounding channels and sedimentation/detention basins both on and offsite. ClosureTurf will have a positive impact on overall storm water quality for sites, allowing them to improve their effluent levels to meet or be well below the regulatory limits.

5) Geotechnical Factors of Safety

ClosureTurf provides additional benefit through increased geotechnical factors of safety on the cover system. On side slopes, these factors of safety provide increased protection from sloughing and veneer failures. On flat surfaces (i.e. top decks), these increased factors of safety are realized through a significant reduction in the soil layer and subsequent loading of any underlying sludge-type waste materials that can reverse drainage and create ponding.

6) Water Conservation

ClosureTurf is a very low maintenance final cover system, eliminating the need of costly re-vegetating and fertilizing of traditional soil/vegetative covers and reducing the evaporative losses and water demands to sustain the closure and its performance. In addition, the system inhibits dust-creation, eliminating the need for wasteful watering practices intended to reduce dust transmission and air particulate pollution.

7) Maintenance Cost Savings

ClosureTurf effectively reduces the maintenance of a final closure system by over 90% through the elimination of maintenance activities and typical erosion repair issues associated with traditional vegetative covers. This savings continues to pay dividends year after year and protects the site from drought cycle or other severe weather damage that can have a detrimental effect on vegetative covers.

8) Land Conservation

Traditional closure methods require the destruction of land to achieve the closure. ClosureTurf optimizes land conservation through the elimination of excavation borrow pits on undisturbed, native land as well as providing acreage for renewable energy sites (i.e. photovoltaic solar panel arrays) that might otherwise need to be constructed in other undeveloped areas.

9) Project Schedule/Installation Rate

ClosureTurf requires fewer resources to complete a final cover closure, from pre-design through final acceptance. ClosureTurf installs significantly faster than traditional soil covers using dramatically lighter and fewer pieces of equipment. This increase in "project velocity" means that owners, operators and their design and construction team can cover more acreage far more efficiently with ClosureTurf than with traditional soil cover systems. In addition, the standardization of engineering and construction details associated with ClosureTurf reduces the burden on the regulatory review and approval process.

10) Longevity

The system is designed for and proven to have a design life over 100 years of the geosynthetic protective ballast component (Engineered Turf) of ClosureTurf (with the membrane lasting many more years beyond the long life of the Engineered Turf component)

ClosureTurf™ Detail Description

ClosureTurf is an environmentally friendly and aesthetically pleasing synthetic turf final cover system designed for long-term performance and a protective ballast for the structured membrane. This system eliminates the challenges of traditional vegetative cover systems such as erosion control, veneer slope stability, and post-closure maintenance. A section of ClosureTurf is shown in Figure 1. Its components include the following from bottom to top:

- 50-mil Super Gripnet Structured HDPE or LLDPE Geomembrane (20% thicker than regulatory requirements);
- Drainage Layer which is Integrated into the Structured Geomembrane;
- Engineered Synthetic Turf (Comprised of Polyethylene Fibers Tufted through Double Layer of a Woven Polypropylene Geotextiles manufactured for high UV and heat resistance); and
- Sand Infill.

The ClosureTurf system is placed directly on top of the soil foundation layer above the waste.

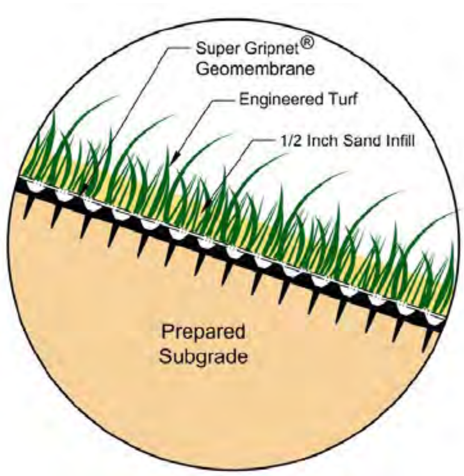


Figure 1 – Cross Section of ClosureTurf™ System

Approvals were based on a demonstration that ClosureTurf exceeds the minimum requirements defined in applicable state or Federal EPA regulations. The minimum technical requirements for Subtitle D Final Cover Systems are contained in 40 CFR 258.60. This regulation allows for a prescriptive (minimum criteria) cover system or an alternative (performance based) cover system. The specific requirements of 40 CFR 258.60 for approval of an alternative final cover system are as follows:

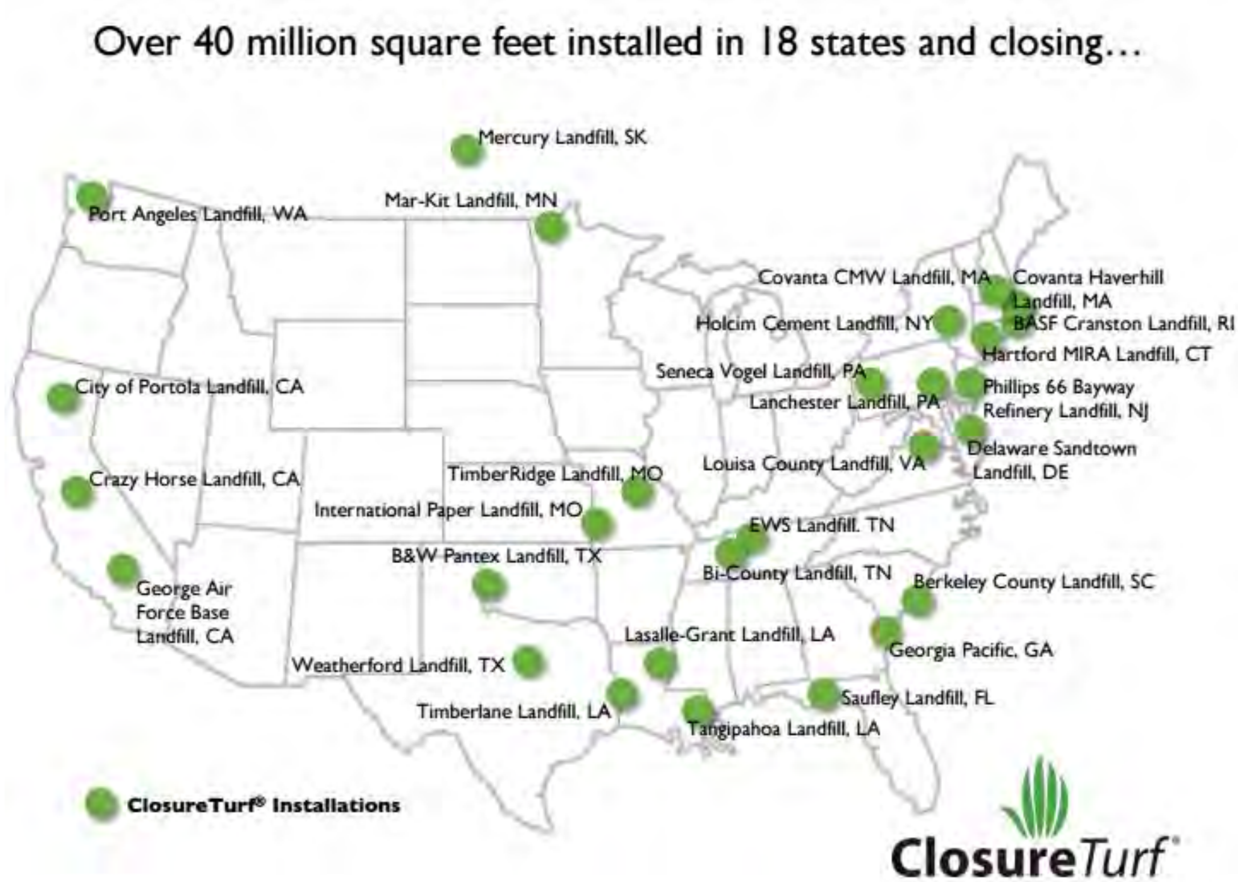
"(B) The Director of an approved State may approve an alternative final cover design that includes:

(1) An infiltration layer that achieves an equivalent reduction in infiltration as the infiltration layer specified in paragraphs (a) (1) and (a) (2) of this section, and

(2) An erosion layer that provides equivalent protection from wind and water erosion as the erosion layer specified in paragraph (a) (3) of this section."

The analyses demonstrate that the ClosureTurf Final Cover has (1) a greater reduction in infiltration than the Prescriptive Subtitle D Cover and (2) provides greater protection from erosion, and provides several orders of magnitude of functional longevity with the **structured membrane that is 20% thicker than the membrane allowed by regulations**. The regulatory approvals, testing and real-world experience has been demonstrated at multiple closures having varying climate conditions as shown in Figure 2 below.

Figure 2 - Completed Projects



Infiltration Equivalency Analyses

Infiltration equivalency through a cover system is typically evaluated using two methodologies. These methodologies are the Hydrologic Evaluation of Landfill Performance (HELP) Model and the Giroud Method[1]. Both of these methods have been used to compare the infiltration performance of the ClosureTurf™ Final Cover System to the Prescriptive Subtitle D Cover. A summary of the results is shown in Table 1.

The results show that the ClosureTurf Final Cover System provides better infiltration protection than the Prescriptive Subtitle D Standard for construction of landfill final closure systems. These results are expected since ClosureTurf™ does not allow hydraulic head to build up over the geomembrane.

Infiltration Equivalency Analyses	ClosureTurf™ Cover System	Prescriptive Subtitle D Cover System
HELP Model for Site in Georgia – Average Annual Infiltration (Cubic Feet / Acre / Year)	8.3	347
Giroud Method with Silty-Sandy Soil below the ClosureTurf™ (Gallons / Acre / Day)	1.33	4.51
Giroud Method with Silty-Sandy Soil with Some Clay below the ClosureTurf™ (Gallons / Acre / Day)	0.24	4.51

Table 1 – Summary of Results for Infiltration Equivalency Analyses

Erosion Control

Rainfall Erosion Control Testing

ClosureTurf was tested at TRI Environmental in accordance with ASTM 6459 - Standard Test Method for Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Hillslopes from Rainfall-Induced Erosion. ClosureTurf™ was tested in a rainfall simulator to an intensity of over 6.5 in/hr with less than 0.04% loss of sand infill.

[1] *Rate Of Liquid Migration Through Defects In A Geomembrane Placed On A Semi-Permeable Medium*, J.P. Giroud, T.D. King, T.R. Sanglerat, T. Hadj-Hamou and M.V. Khire, Geosynthetics International 1997, Vol. 4, Nos. 3-4.

Figure 3 – Rainfall Erosion Control Testing on ClosureTurf (3H:1V Slope)

The typical design criterion for sediment runoff on a traditional landfill soil cover is 3 tons/acre/year. The measured loss of sand infill (0.04%) of the ClosureTurf is approximately 0.03 tons/acre for a 6.5 in/hr rainfall intensity. Using ClosureTurf will significantly reduce sediment loads and runoff turbidity. Also, the ClosureTurf System filters the storm water and provides "clean" runoff as shown in the testing samples in Figure 4 below.

Enhanced Water Quality

Figure 4 – Storm Water Quality Sampling before and after ClosureTurf install

Parameter	Area with Soil Cover	Area with ClosureTurf™
Turbidity (NTU)	371	11
TSS (mg/L)	349	<4
pH	6.5	7.3
TOC (mg/L)	174	1
TRI (mg/L)	16	0.5

Table 3 – Analytical Results from Storm Water Samples at Tangipahoa Landfill

Large Scale Flume Testing of HydroTurf®

In areas of channelized flow (bench drains, down chutes, and perimeter channels), Watershed Geosynthetics suggests that the ClosureTurf be infilled with HydroBinder® (sand cement infill) instead of just sand. We refer to the resulting product as HydroTurf. HydroTurf has been tested at Colorado State University Engineering Research Center (CSU).

CSU tested HydroTurf in accordance with ASTM D 7277 – Standard Test Method for Performance Testing of Articulated Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow. The results of the testing were analyzed in accordance with ASTM D 7276 - Standard Guide for Analysis and Interpretation of Test Data for Articulating Concrete Block (ACB) Revetment Systems in Open Channel Flow. Testing was performed to the 5-ft overtop flume capacity which resulted in over 29 fps in velocity and over 8.8 psf in shear stress. The photos in Figure 5 show this steady state testing being performed.

Figure 5 – Steady State Hydraulic Testing of HydroTurf™ at CSU

Full-scale Wave Overtopping Testing for Side Slope Protection was also performed on the HydroTurf at CSU. CSU has the world's largest Wave Overtopping Simulator which they developed for the US Army Corp of Engineers. Testing was performed on HydroTurf for 13 hours with 9 hours at the maximum capacity of the simulator (4.0 cfs/ft which represents a generic hurricane with a 0.2 percent annual exceedance probability – 500-year event). The photos in Figure 6 show wave overtop testing on the HydroTurf.

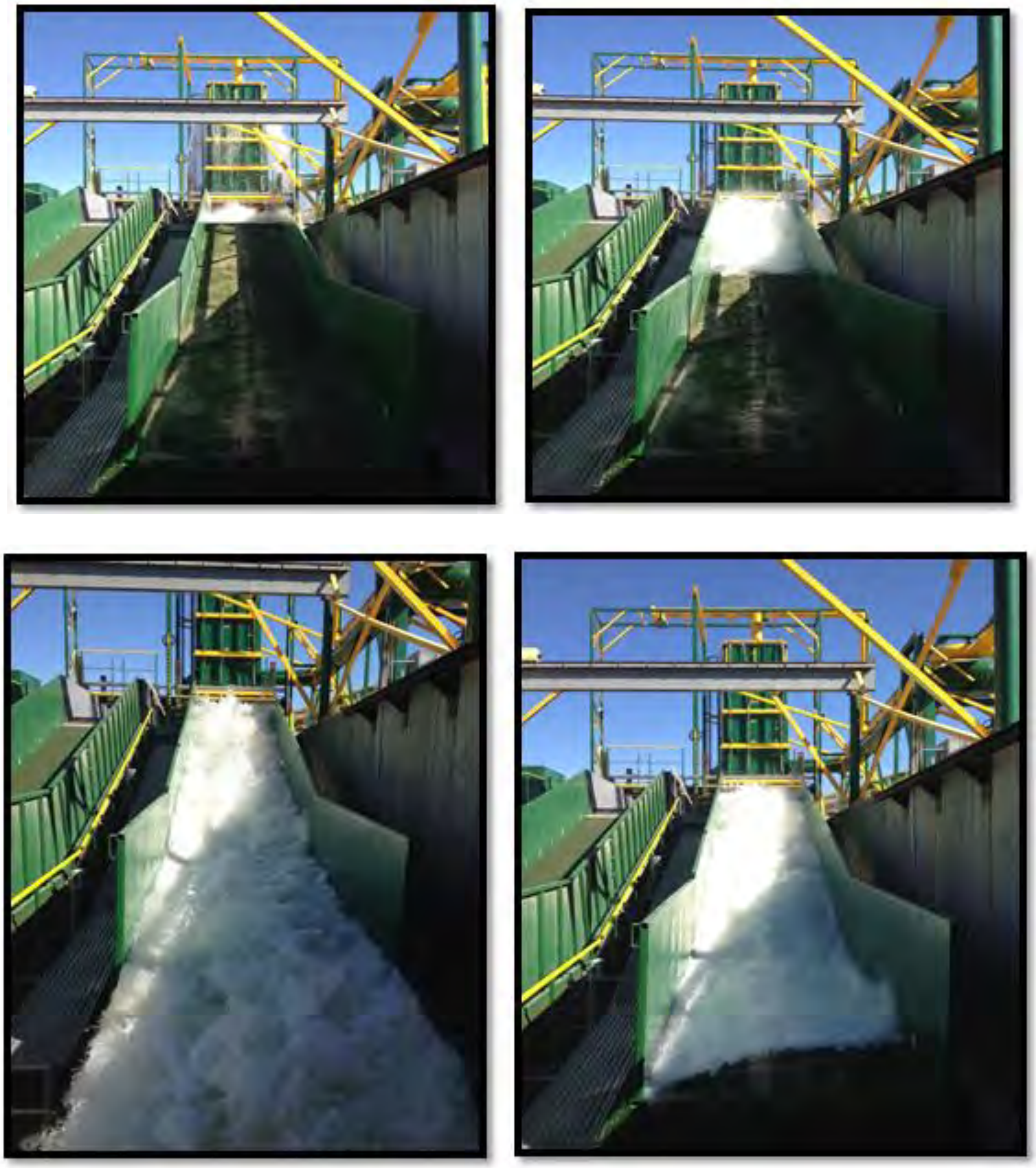


Figure 6 – Wave Overtop Hydraulic Testing of HydroTurf® at CSU

Longevity and Protection Provided by ClosureTurf™

ClosureTurf is **not an exposed cover system**, it is a **hybrid system** that provides full protection of the most critical element of the closure system. ClosureTurf differs from exposed geomembrane systems as follows:

Access and drivability of exposed geomembrane systems are severely limited without means of protecting the geomembrane. In addition, exposed geomembranes are vulnerable to wildlife trafficking. The engineered Turf component serves as a protective ballast providing physical protection and weathering protection.

Since ClosureTurf looks and feels like natural vegetation, it is significantly more aesthetically pleasing than an exposed geomembrane system with hydraulic parameters that do not create fast time of concentrations and energy dissipation issues to the degree of that of exposed membranes.

ClosureTurf has a longer functional longevity than exposed geomembrane systems. For ClosureTurf, the synthetic turf layer provides protection of the structured geomembrane such that it is not exposed to the elements. If properly maintained, the **Engineered Turf layer will have a 100+ year functional longevity**. The results for 10 years of independent weathering data for the artificial turf yarns are shown in Figure 7. When this data is extrapolated out to 100 years, the yarn has an approximate 65% retained tensile strength. In other words, the design half-life of the engineered turf layer far exceeds 176 years. This longevity has been independently evaluated by multiple organizations who are experienced in the longevity performance of geosynthetics.

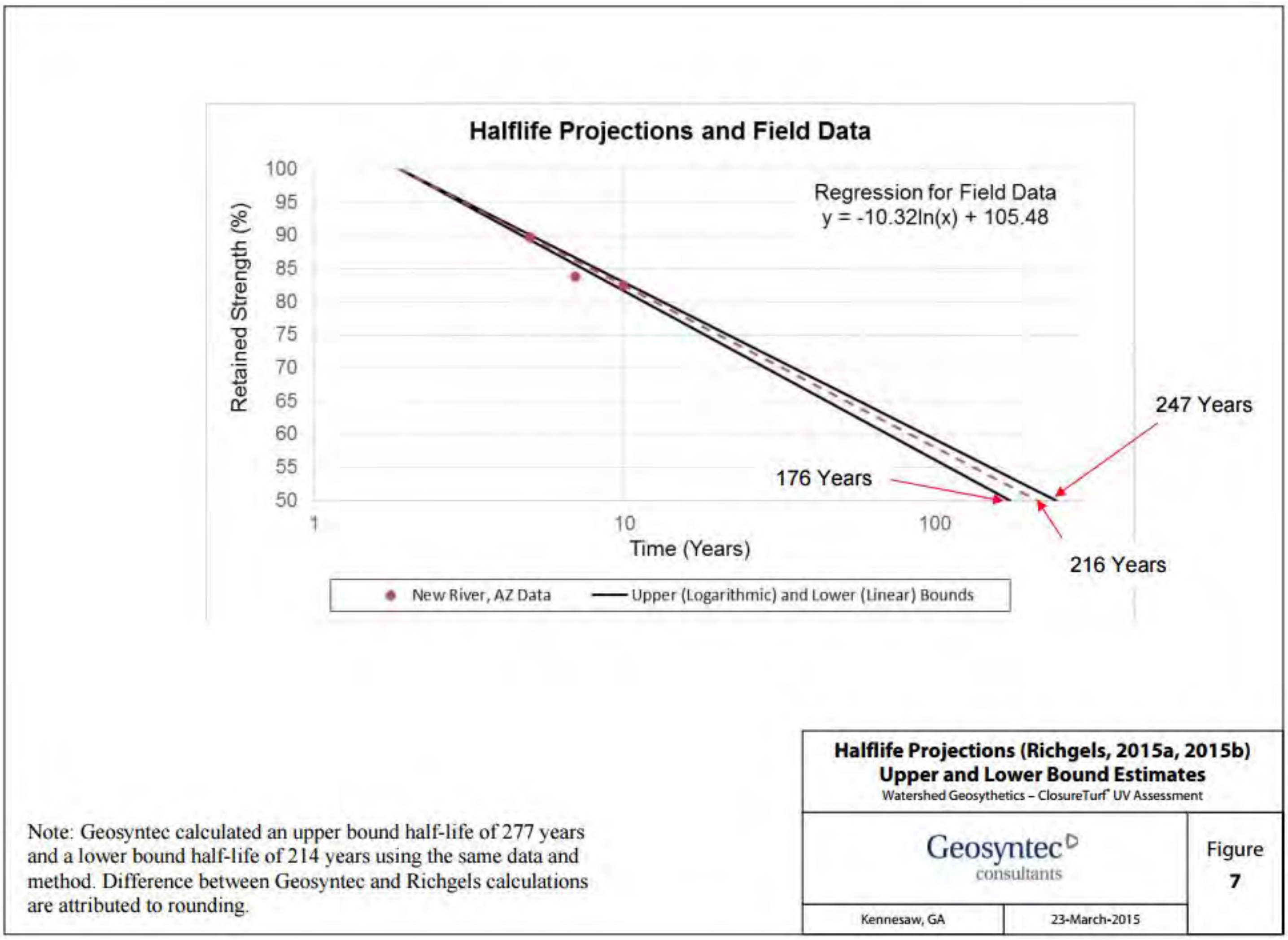


Figure 7 - Independent longevity analysis projection

Static and Dynamic Load Evaluations

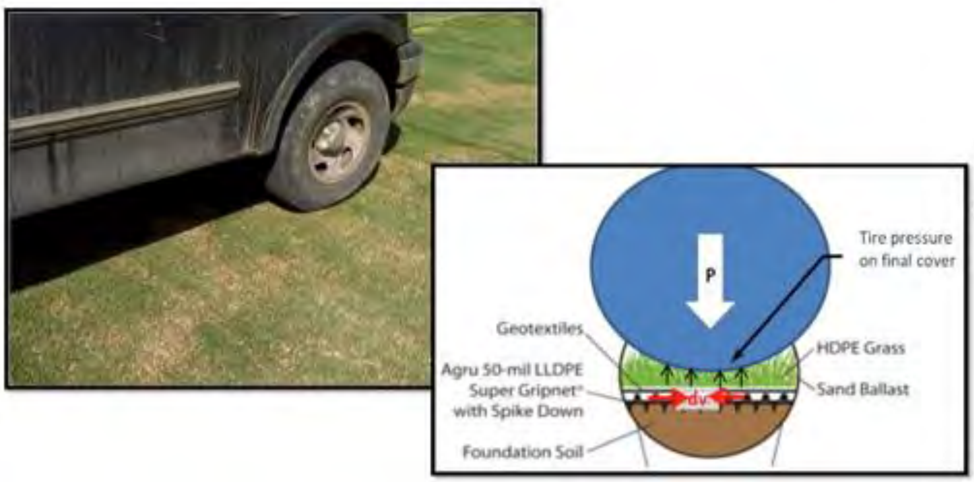
Traffic Loading Evaluation

Rubber tired vehicles, and some steel-track equipment, are allowed to drive on the ClosureTurf System. Typically, on slopes we suggest vehicles with ground pressures less than 60 psi, and on flat decks (2% or less) and designed access roads, we suggest vehicles with tire pressures less than 100 psi. Detailed calculations for puncture of the geomembrane from wheel loading have been performed as well as lateral movement on account of vehicle braking have been performed on numerous applications for final cover.

Traffic Loading Evaluation

Light Vehicle – Pick Up

Heavy Vehicle – Fire Engine

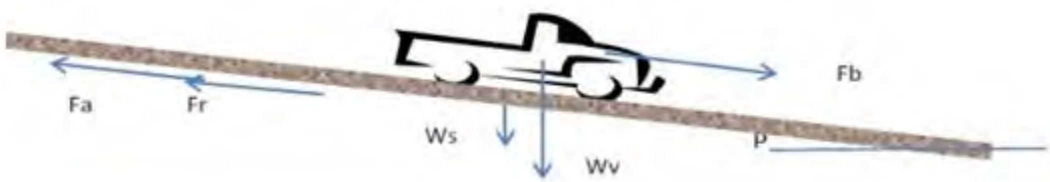


Traffic Loading Evaluation Continued

	Light Vehicle (Pick Up Truck)	Heavy Vehicle (Fire Engine)
Applied Pressure / Load – Deformation of Geotextile Backing*	4.37	1.64
Tensile Strength (Lateral Movement)*	1.85	1.90****
Puncture Resistance – Geotextile Backing Component*	239	90
Puncture Resistance on Roadways – Geomembrane Component	4 oz/sy GT	12 oz/sy GT

* Factor of Safety
** Methodology per Koerner (2005)
*** Reduction Factors of 1.5 for Installation Damage
**** 200 lb geotextile required

Traffic Loading Evaluation – Breaking



Vehicle	Slope Angle	Static FS	Dynamic FS
Fire Engine	8 Degrees	4.6	1.8
Pick Up Truck	18 Degrees (3H: 1V)	2.0	1.2

Aerodynamic Evaluation

ClosureTurf has features that help mitigate the forces of wind. These include a porous surface to break the vacuum, and turf blades that will increase the aerodynamic boundary conditions and react against the wind causing a resistance to the uplift component.

The ClosureTurf System was evaluated in the wind tunnel at the Georgia Tech Research Institute (GTRI). It was tested up to 120 mph without uplift. Based on these results, the ClosureTurf System is projected to withstand 150+ mph winds when properly designed. The photo in Figure 8 shows the test at 170 fps (120 mph).

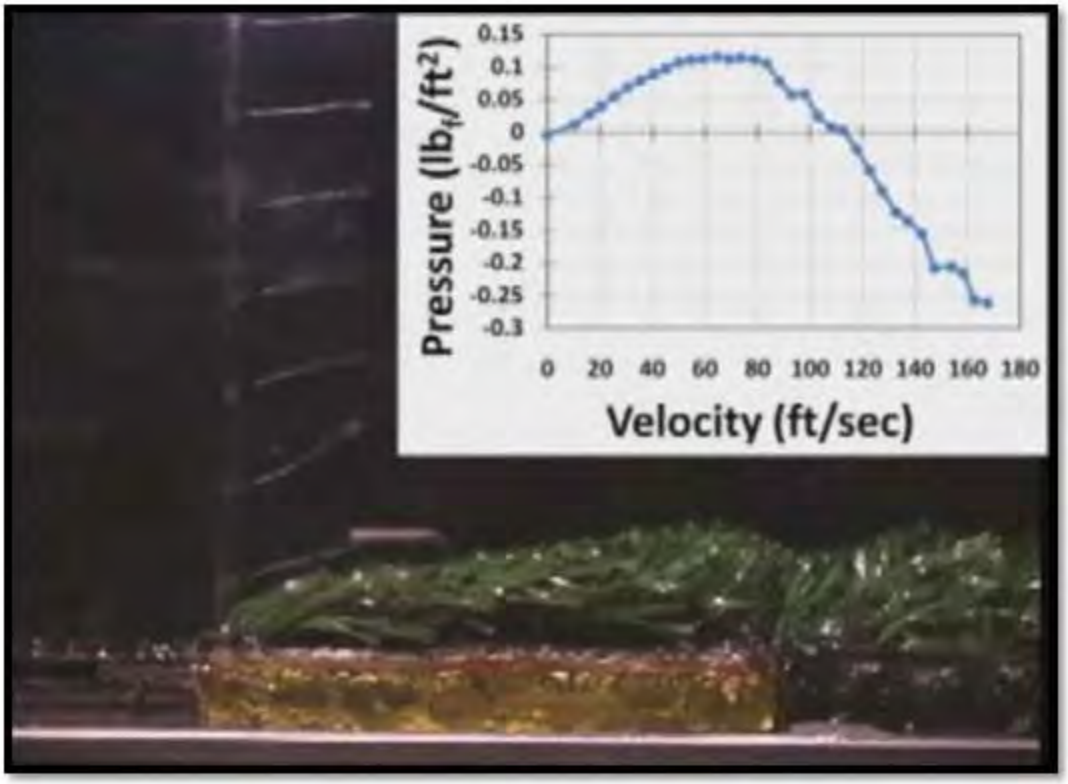


Figure 8 – Aerodynamic Evaluation of ClosureTurf at GTRI

Carbon Footprint

ClosureTurf has approximately 1/5 the carbon footprint of the Subtitle D traditional prescription cover system. The factors influencing the carbon footprint, and other environmental impacts, are related to reduction of 350 haul trucks per acre that is normally required to haul the adequate amount of cover to meet the specifications of the regulatory prescriptive cover. Other impacts include the destruction of land for borrow soil, sediment from land disturbance. The details of the carbon footprint calculations are shown in the following chart in Figure 9.

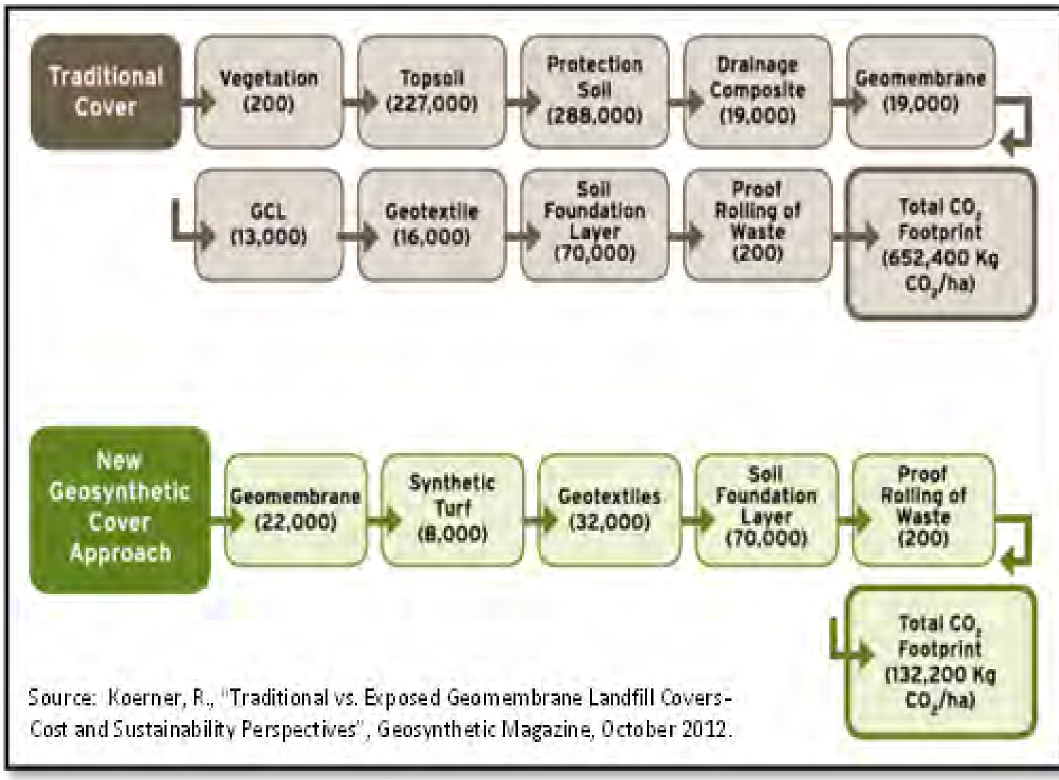


Figure 9 – Carbon Footprint Evaluation of ClosureTurf vs. Traditional Cover

Emission Control

The ClosureTurf system prevents fugitive emissions by totally encapsulating the closed areas. When integrated with conventional gas collection systems, higher collection efficiency along with reduced oxidation potential of the waste mass can be expected. If the patented ClosureTurf Surficial Gas Collection system is utilized, high collection efficiency, no oxidation potential along with significant reduction in condensate generation can be realized. Slope stability issues associated with landfill gas buildup beneath the soil/membrane (prescriptive) caps are diminished with the ClosureTurf system as a result of no soil loading, there is nothing to fail. The ClosureTurf system also has patented designed automatic relief valves to compensate for gas buildup pressure during periods of malfunction of the primary gas collection systems.

Supporting Documentation

All the information presented here is available for review at www.watershedgeo.com, or can be provided as a hardcopy binder as requested for a permit application. Please contact our engineering services team at 770-777-0386 for any questions or a request for documentation.

Live Binder – ClosureTurf Technical Binder - http://www.livebinders.com/play/play/1981577 - Access Key for private binder: closureturf.

EXHIBIT 18

TRI/ENVIRONMENTAL, INC.
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Project: ASTM D 6459 (single replicate)
Client: ClosureTurf
Test Date: 7/20/2015
Rainfall Rates: 2,4,6 in/hr (target); 20 minutes at each intensity (60 min. total)
Bed Size & Slope: 8-ft wide x 40-ft long; 3H:1V
Sand Ballast Layer, lbs (dry): 1400 (approximately 1/2-inch thick, hand spread)

Slope 1

Plot	Intensity (in/hr)	Runoff (gallons)	Cumulative R-Factor	Cumulative Soil Loss (lbs/slope)	Sediment Yield (tons/acre)	% of Ballast in Runoff/Seepage
ClosureTurf with Ballast Sand + Cement Spray	2.09	90	7.03	0.048	0.003	0.01%
	4.06	212	52.48	0.100	0.007	
	5.98	300	164.69	0.112	0.008	

Time (min)	Cumulative Rainfall (in)	Cumulative Runoff (in)	Peak Runoff (cfs)	CN[1]	Rational "C"[2]
20	0.70	0.45	0.013	97.4	0.84
40	2.05	1.52	0.026	94.9	0.87
60	4.04	3.02	0.038	90.7	0.86

1.) The effective runoff curve number was determined by solving for S in the equation Q = [(P-0.2S)2/(P+0.8S)] where Q is the depth of runoff (in) and P is the rainfall depth (in). Then, CN = 1000/(S+10).

2.) The rational "C" coefficient was determined by solving for C in Q = C I A where Q is the peak discharge rate (cfs), I is the peak rainfall intensity (in/hr) and A is the drainage area (acre).

Note The testing is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose.

CJS 7/24/15
Quality Review / Date


Test Slope Prepared and Liner Installed (Typical)

Slope Ready for Rainfall

Sand/Cement Ballasted Slope - After Rainfall

APPENDIX - DATA

TRI

DDRF Rainfall Testing

Slope #: 2 | **Target Rain: 2 in/hr**

Date: 20-Jul-15
Start Rain: 9:28 AM
End Rain: 9:48 AM
Sampling interval: 0:03
End Runoff: 9:51 AM
Rain Time (min): 20.00
Test Time (min): 23.00
Product: Closure Turf
Descr.: Sand Fill w/ Cement
Lot #:
Anchors:
Anchorage:

TOP OF SLOPE
Set valves to _16___ psi.
(circle "x" for open valves)

w_{c1} = #DIV/0!
d = 18 mm
i = 2.13 in/hr

x X x x
P = 10 psi

A

B P = 10 — X X x x
C P = 10 psi — X X x x
D P = 10 psi — x X x x
E P = 10 psi — x x X x
F P = 10 psi — x X x x
G P = 10 psi — x x X x
H P = 10 psi — x x X x
I P = 10 psi — x x X X
J P = 10 psi — x x X X

d = 18 mm
i = 2.13 in/hr
w_{c3} = #REF!

d = 17 mm
i = 2.01 in/hr
w_{c2} = #REF!

Temp. 92 deg
Hum. 61 %

Average Depth: 18 mm
Avg Rainfall Intensity: 2.09 in/hr

Sediment Concentration Grab Samples Followed by Runoff Rate Measurements

#	Time	Sample Taken
1	3:00	X
2	6:00	X
3	9:00	X
4	12:00	X
5	15:00	X
6	18:00	X
7		
8		
9		
10		
11		
12		
13		
14		
15		
12		
13		
14		
15		

Runoff Rate Measurements

#	Time (min.)	Time to Collect 1 Gallon, Seconds
1	2	396
2	10	10
3	12	9
4	14	8
5	16	7
6	18	7
7	20	6
8		
9		
10		
11		
12		
13		
14		
15		
12		
13		
14		
15		

Notes:
0 mph breeze. Approx
90 gal collected.

TRI

DDRF Rainfall Testing

Slope #: 2 | **Target Rain: 4 in/hr**

Date: 20-Jul-15

Start Rain: 9:53 AM | End Rain: 10:13 AM

Sampling interval: 0:02 | End Runoff: 10:16 AM

Rain Time (min): 20.00 | Test Time (min): 23.00

Product: Closure Turf | Descr.: Sand Fill w/ Cement

Lot #: | Anchors: | Anchorage:

TOP OF SLOPE | **Set valves to 16 psi.**

(circle "x" for open valves)

w_{c1} = #DIV/0!

d = 34 mm

i = 4.02 in/hr

X X x x

P = 12 psi

A

B P = 10 psi — X X X x

C X X X x — P = 10 psi

D P = 10 psi — X X x x

E X X x x — P = 10 psi

F P = 10 psi — X X x x

G x x X X — P = 10 psi

H P = 10 psi — x x X X

I x X X X — P = 10 psi

J P = 10 psi — x X X X

d = 35 mm

i = 4.13 in/hr

w_{c3} = #REF!

d = 34 mm

i = 4.02 in/hr

w_{c2} = #REF!

Temp. 91 deg

Hum. 71 %

Average Depth: 34 mm

Avg Rainfall Intensity: 4.06 in/hr

Sediment Concentration Grab Samples Followed by Runoff Rate Measurements

#	Time	Sample Taken
1	0:00	X
2	0:00	X
3	0:00	X
4	0:00	X
5	0:00	X
6	0:00	X
7	0:00	X
8	0:00	X
9	0:00	X
10	0:00	X
11		
12		
13		
14		
15		
12		
13		
14		
15		

Runoff Rate Measurements

#	Time (min)	Time to Collect 1 Gallon, **Seconds**
1	2	7
2	4	6
3	6	6
4	8	6
5	10	6
6	12	6
7	14	6
8	16	6
9	18	6
10	20	6
11		
12		
13		
14		
15		
12		
13		
14		
15		

Notes:

0 mph breeze. Approx

210 gal collected.

TRI

DDRF Rainfall Testing

Slope #: 2 | **Target Rain: 6 in/hr**

Date: 20-Jul-15
Start Rain: 10:20 AM | End Rain: 10:40 AM
Sampling interval: 0:02 | End Runoff: 10:44 AM
Rain Time (min): 20.00 | Test Time (min): 24.00
Product: Closure Turf | Descr:. Sand Fill w/ Cement
Lot #: | Anchors: | Anchorage:

TOP OF SLOPE | **Set valves to 16 psi.**

(circle "x" for open valves)

w_{c1} = #DIV/0!

d = 51 mm
i = 6.02 in/hr

A: X X X x, P = 10 psi

B: P = 10 psi — X X X X
C: P = 10 psi — X X X X
D: P = 10 psi — X X X x
E: P = 10 psi — X X X x
F: P = 10 psi — X X X x
G: P = 10 psi — x X X X
H: P = 10 psi — x X X X
I: P = 10 psi — X X X X
J: P = 10 psi — X X X X

d = 51 mm
i = 6.02 in/hr
w_{c3} = #REF!

d = 50 mm
i = 5.91 in/hr
w_{c2} = #REF!

Temp. 91 deg
Hum. 76 %

Average Depth: 51 mm
Avg Rainfall Intensity: 5.98 in/hr

Sediment Concentration Grab Samples Followed by Runoff Rate Measurements

#	Time	Sample Taken
1	0:00	X
2	0:00	X
3	0:00	X
4	0:00	X
5	0:00	X
6	0:00	X
7	0:00	X
8	0:00	X
9	0:00	X
10	0:00	X
11		
12		
13		
14		
15		
12		
13		
14		
15		

Runoff Rate Measurements

#	Time (min)	Time to Collect 1 Gallon, Seconds
1	2	5
2	4	5
3	6	5
4	8	5
5	10	5
6	12	4
7	14	4
8	16	4
9	18	4
10	20	4
11		
12		
13		
14		
15		
12		
13		
14		
15		

Notes:
0 mph breeze. Approx
300 gal collected.

Slope #2 - Sediment Concentration

		Sample Number	Test Time, minutes	Total Weight, g	Decanted Weight, g	Dry Weight, g	Bottle Weight, g	Dry Sediment Weight, mg	Total Collected Water Wt., g	Total Collected Volume of Water, l	Sediment Concentration, mg/l	Runoff Sampling Time	Time to Collect 1 gal	Associated Runoff, gal	Associated Sediment Conc, mg/l	Associated Solids Loss, lbs
2.09	in/hr	avg														
20-Jul-15		2-1	3.00	364.38	228.12	151.43	151.28	150.00	212.95	0.21	704.39	2.00	396	1.30	528.22	0.01
		2-2	6.00	371.45	203.91	149.33	149.12	210.00	222.12	0.22	945.43	10.00	10	9.40		0.00
		2-3	9.00	356.49	194.91	152.2	152.09	110.00	204.29	0.20	538.45	12.00	9	13.22		0.00
		2-4	12.00	363.02	194.27	150.33	150.24	90.00	212.69	0.21	423.15	14.00	8	14.88		0.00
		2-5	15.00	353.7	190.47	151.94	151.89	50.00	201.76	0.20	247.82	16.00	7	17.00		0.00
		2-6	18.00	345.41	177.43	151.89	151.83	60.00	193.52	0.19	310.05	18.00	7	17.14		0.00
										AVG =	**528.22**	16.00	7	17.00	310.05	0.04
4.06	in/hr	avg												**Total Solids Lost:**		**0.05**
20-Jul-15		4-1	2.00	368.32	171.84	151.76	151.69	70.00	216.56	0.22	323.24	2.00	7	18.14	323.24	0.05
		4-2	4.00	366.04	194.49	151.47	151.42	50.00	214.57	0.21	233.02	4.00	6	19.83	233.02	0.04
		4-3	6.00	365.03	190.75	150.95	150.89	60.00	214.08	0.21	280.27	6.00	6	20.00	280.27	0.05
		4-4	8.00	367	174.41	151.51	151.48	30.00	215.49	0.22	139.22	8.00	6	20.00	139.22	0.02
		4-5	10.00	367.22	183.34	150.77	150.71	60.00	216.45	0.22	277.20	10.00	6	20.00	277.20	0.05
		4-6	12.00	371.45	195.78	151.33	151.23	100.00	220.12	0.22	454.30	12.00	6	20.00	454.30	0.08
		4-7	14.00	365.23	180.44	151.98	151.92	60.00	213.25	0.21	281.36	14.00	6	20.00	281.36	0.05
		4-8	16.00	372.9	176.08	148.75	148.66	90.00	224.15	0.22	401.52	16.00	6	20.00	401.52	0.07
		4-9	18.00	360.96	179.15	151.55	151.49	60.00	209.41	0.21	286.52	18.00	6	20.00	286.52	0.05
		4-10	20.00	365.6	164.05	151.22	151.17	50.00	214.38	0.21	233.23	20.00	6	20.00	233.23	0.04
										AVG =	**290.99**	23.00	6	14.50	233.23	0.03
5.98	in/hr	avg												**Total Solids Lost:**		**0.51**
20-Jul-15		6-1	2.00	362.53	165.35	150.9	150.86	40.00	211.63	0.21	189.01	2.00	5.00	25.00	189.01	0.04
		6-2	4.00	364.27	176.53	150.72	150.68	40.00	213.55	0.21	187.31	4.00	5.00	24.00	187.31	0.04
		6-3	6.00	370.27	164.05	150	149.97	30.00	220.27	0.22	136.20	6.00	5.00	24.00	136.20	0.03
		6-4	8.00	367.42	169.02	151.84	151.78	60.00	215.58	0.22	278.32	8.00	5.00	24.00	278.32	0.06
		6-5	10.00	364.55	182.24	151.18	151.14	40.00	213.37	0.21	187.47	10.00	5.00	24.00	187.47	0.04
		6-6	12.00	374.89	176.4	149.64	149.62	20.00	225.25	0.23	88.79	12.00	4.00	29.75	88.79	0.02
		6-7	14.00	374.2	169.57	149.68	149.65	30.00	224.52	0.22	133.62	14.00	4.00	30.00	133.62	0.03
		6-8	16.00	370.02	168.6	151.24	151.2	40.00	218.78	0.22	182.83	16.00	4.00	30.00	182.83	0.05
		6-9	18.00	368.67	171.96	150.75	150.73	20.00	217.92	0.22	91.78	18.00	4.00	30.00	91.78	0.02
		6-10	20.00	381.88	168.89	151.14	151.05	90.00	230.74	0.23	390.05	20.00	4.00	30.00	390.05	0.10
										AVG =	**186.54**	24.00	4	29.50	390.05	0.10
														Total Solids Lost:		**0.52**

TRI

20-Jul-15

Slope #2

Sample Number	Test Time, minutes	Time per Gallon, sec	Interval Time, min	Total Time, min	Collection Mid-Time, min	Runoff Rate, gal/min	Associated Runoff, gal	Cumulative Runoff, gal	
2.09 in/hr									
2	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	
2-1	2.00	396	8.60	8.60	5.30	0.15	1.30	1.30	
2-2	10.00	10	1.57	10.17	10.08	6.00	9.40	10.70	
2-3	12.00	9	1.98	12.15	12.08	6.67	13.22	23.93	
2-4	14.00	8	1.98	14.13	28.13	7.50	14.88	38.80	
2-5	16.00	7	1.98	16.12	32.12	8.57	17.00	55.80	
2-6	18.00	7	2.00	18.12	36.12	8.57	17.14	72.94	
2-end	23.00		4.88	23.00		4.29	17.00	**89.94**	**Total Collected Runoff (approx)**
4.06 in/hr									
4	0	0	0.00	0.00	0.00	0.00	0.00	0.00	
4-1	2	7	2.12	2.12	2.06	8.57	18.14	18.14	
4-2	4	6	1.98	4.10	4.05	10.00	19.83	37.98	
4-3	6	6	2.00	6.10	6.05	10.00	20.00	57.98	
4-4	8	6	2.00	8.10	8.05	10.00	20.00	77.98	
4-5	10	6	2.00	10.10	10.05	10.00	20.00	97.98	
4-6	12	6	2.00	12.10	12.05	10.00	20.00	117.98	
4-7	14	6	2.00	14.10	14.05	10.00	20.00	137.98	
4-8	16	6	2.00	16.10	16.05	10.00	20.00	157.98	
4-9	18	6	2.00	18.10	18.05	10.00	20.00	177.98	
4-10	20	6	2.00	20.10	20.05	10.00	20.00	197.98	
4-end	23.00		2.90	23.00		5.00	14.50	**212.48**	**Total Collected Runoff (approx)**
5.98 in/hr									
6	0	0	0.00	0.00	0.00	0.00	0.00	0.00	
6-1	2	5	2.08	2.08	2.04	12.00	25.00	25.00	
6-2	4	5	2.00	4.08	4.04	12.00	24.00	49.00	
6-3	6	5	2.00	6.08	6.04	12.00	24.00	73.00	
6-4	8	5	2.00	8.08	8.04	12.00	24.00	97.00	
6-5	10	5	2.00	10.08	10.04	12.00	24.00	121.00	
6-6	12	4	1.98	12.07	12.03	15.00	29.75	150.75	
6-7	14	4	2.00	14.07	14.03	15.00	30.00	180.75	
6-8	16	4	2.00	16.07	16.03	15.00	30.00	210.75	
6-9	18	4	2.00	18.07	18.03	15.00	30.00	240.75	
6-10	20	4	2.00	20.07	20.03	15.00	30.00	270.75	
6-end	24.00		3.93	24.00		7.50	29.50	**300.25**	**Total Collected Runoff (approx)**

TRI

SLOPE #2 - Sediment Weights

Total Dry Sediments:	0.05	
2 in/hr	Collected	Typ. TSS in Decanted Collected Runoff, lb/gal
Wt. Of pan + wet soil, lb		
Wt. Of pan + dry soil, lb	0.048	
Wt. Of pan, lb	0	
Wt. Of dry soil, lb	0.048	0
Wt. Of water, lb		Collected Sediments, gal
Water Content, w%		
Total Wet Sediments, lb		
% dry solids		11.7
Dry Collected Sediments, lbs	0.05	

Total Dry Sediments:	0.05	
4 in/hr	Collected	Typ. TSS in Decanted Collected Runoff, lb/gal
Wt. Of pan + wet soil, lb		
Wt. Of pan + dry soil, lb	0.052	
Wt. Of pan, lb	0	
Wt. Of dry soil, lb	0.052	0
Wt. Of water, lb		Collected Sediments, gal
Water Content, w%		
Total Wet Sediments, lb		
% dry solids		141.2
Dry Collected Sediments, lbs	0.05	

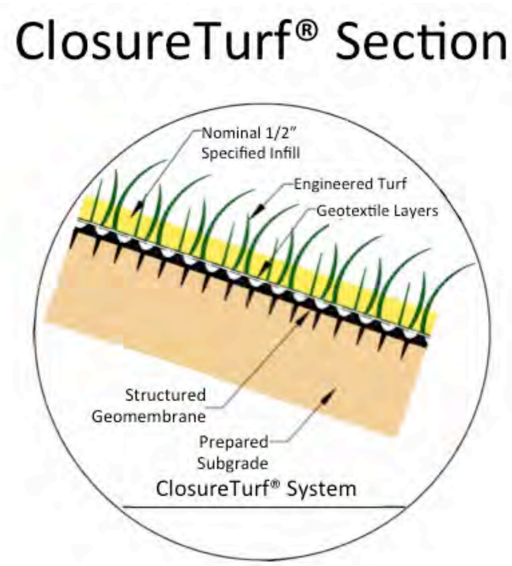
Total Dry Sediments:	0.01	
6 in/hr	Collected	Typ. TSS in Decanted Collected Runoff, lb/gal
Wt. Of pan + wet soil, lb		
Wt. Of pan + dry soil, lb	0.012	
Wt. Of pan, lb	0	
Wt. Of dry soil, lb	0.012	0
Wt. Of water, lb		Collected Sediments, gal
Water Content, w%		
Total Wet Sediments, lb		
% dry solids		287.1
Dry Collected Sediments, lbs	0.01	

EXHIBIT 19

Design Life of ClosureTurf®

The ClosureTurf® Final Cover System is conservatively projected to last well over one hundred (100) years, provided it is installed and maintained in accordance with Watershed Geosynthetics' standard specifications. This duration exceeds the current post-closure regulatory period of 30 years by 3.3 times. During that time, the average maintenance requirements of the ClosureTurf system will be roughly 15% of the requirements of a prescriptive soil cover system.

The actual data indicates that the engineered synthetic turf component will last over two hundred years. To better understand these longevity predictions, it is helpful to break down the system into its components and explain the function of each of the components. Below is a cross-section of the ClosureTurf system to guide this discussion.



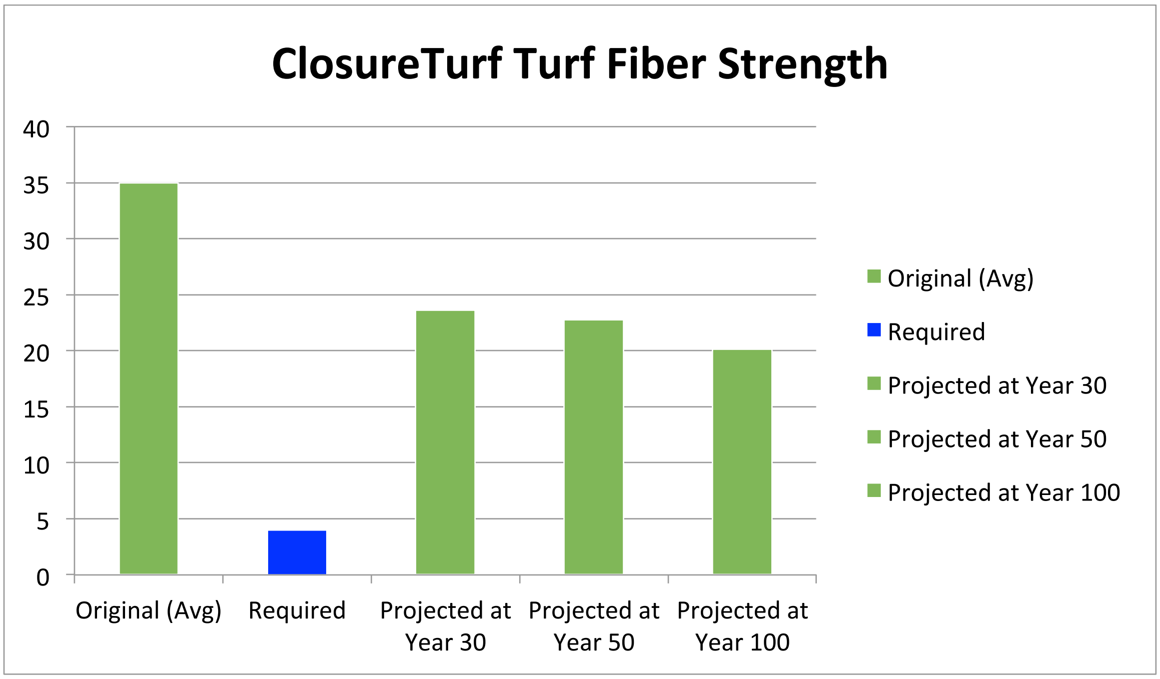
Starting at the prepared subgrade and working up through the cross-section of the system, the first component is the structured geomembrane. This is the impermeable liner that is, essentially, doing the "heavy lifting" of the actual environmental containment. As long as this layer is protected from UV and trafficking stresses, it will last hundreds of years, based upon industry research.

Moving upward through the cross-section, the next component is the engineered synthetic turf layer, also known as a tufted geosynthetic. This component is comprised of two distinct parts- one, a double-layer of UV-enhanced, woven geotextiles; and two, polyethylene fibers that are tufted into the woven geotextiles.

The final component of the ClosureTurf system is the specified infill. This material is granular and rests above the geotextile layers and within the individual turf fibers of the engineered turf. The specified infill provides UV shielding and impact stress cushioning of the engineered synthetic turf. The turf fibers hold the infill in place, preventing it from migrating- not unlike how beach grass holds sand in place on sand dunes in coastal environments.

The ClosureTurf design life is assured through the documented longevity and correlating projections of the polyethylene fibers. As long as these fibers are intact and possess a minimum amount of tensile strength (i.e. 3 lbs per fiber), then they will hold the infill in place. As long as the infill remains in place, then the dual-layer of UV-enhanced woven geotextiles will remain intact and in place on top of the structured geomembrane, which means the geomembrane will realize it's full design life of several hundred years. As can be seen, it is the longevity of the polyethylene turf fibers that dictate the design life of the turf layer, and therefore the overall system.

Extensive testing on the turf fibers indicates they will last over two hundred years. At year 100, they are projected to have approximately 60% of their original tensile strength. The original tensile strength of the turf fibers is 35 lbs per fiber, on average. At 60%, that means they still have 21 lbs, or roughly 5 times the strength necessary to perform in application. A visual representation of these values is shown below.



Given this information, it is reasonable to assume that the standard maintenance activities associated with ClosureTurf are all that will be required for the system for well over the first one hundred years of the installation.

The ClosureTurf system requires no resources to establish, repair nor maintain any vegetation. The average cost for maintenance of this system will typically be 10% of the costs for maintenance of a prescriptive soil cover system. Standard maintenance for ClosureTurf includes primarily visual observation during periodic, pre-determined frequencies (i.e. once per quarter or once per year). At five-year intervals, it should be expect that a small percentage (i.e. 2%) of sand infill may need to be re-graded into place. Real world data of existing ClosureTurf installations suggest a budgetary amount of maintenance is $100-$200 per acre per year, on average. Prescriptive soil cover systems typically run $1,000-$1,500 per acre per year, on average.

EXHIBIT 20

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

Project: ClosureTurf with Sand-Cement Infill - Channel Lining
Client: Watershed Geo
Test Dates: 7/20/2015 7/31/2015
Shear Range: 2.0 - 10.0+ psf (target)
Flume Size & Slope: 2-ft wide x 40-ft long; 10% Bed (Shear Levels 1 - 4)
2-ft wide x 40-ft long; 20% Bed (Shear Levels 5 - 8)
Event: 30 minutes at each shear

Shear Level	Flow depth (in)	Flow velocity (fps)	Flow (cfs)	Manning's roughness, n	Max Bed Shear Stress (psf)	CSLI (in)	Cumm. CSLI, (in)
1	1.86	3.68	1.14	0.037	0.96	0.00	0.00
2	2.56	5.19	2.21	0.032	1.30	0.00	0.00
3	3.76	7.93	4.96	0.027	1.90	0.00	0.00
4	6.91	14.57	16.78	0.022	3.53	0.00	0.01
5	1.94	5.13	1.66	0.039	1.99	0.00	0.00
6	3.87	10.64	6.86	0.029	3.86	0.00	0.00
7	5.80	17.29	16.72	0.023	5.37	0.03	0.03
8	9.63	25.09	40.27	0.020	7.62	0.03	0.07

Observations:

Shears 1 - 3 & 5 - 7	The flow was laminar and uniform through the test reach. There was no observable loss or cracking of fill material. Shear events appeared to have no effect on the system.
Shears 4 & 8	Flow was turbulent entering the channel but became reasonably laminar by Section 6. Still, there was no observable loss or cracking of fill material. Even these highest shear events appeared to have no effect on the system.


Channel Prepared for Testing


Highest Shear = Maximum Flow in 20% Flume


After Highest Shear

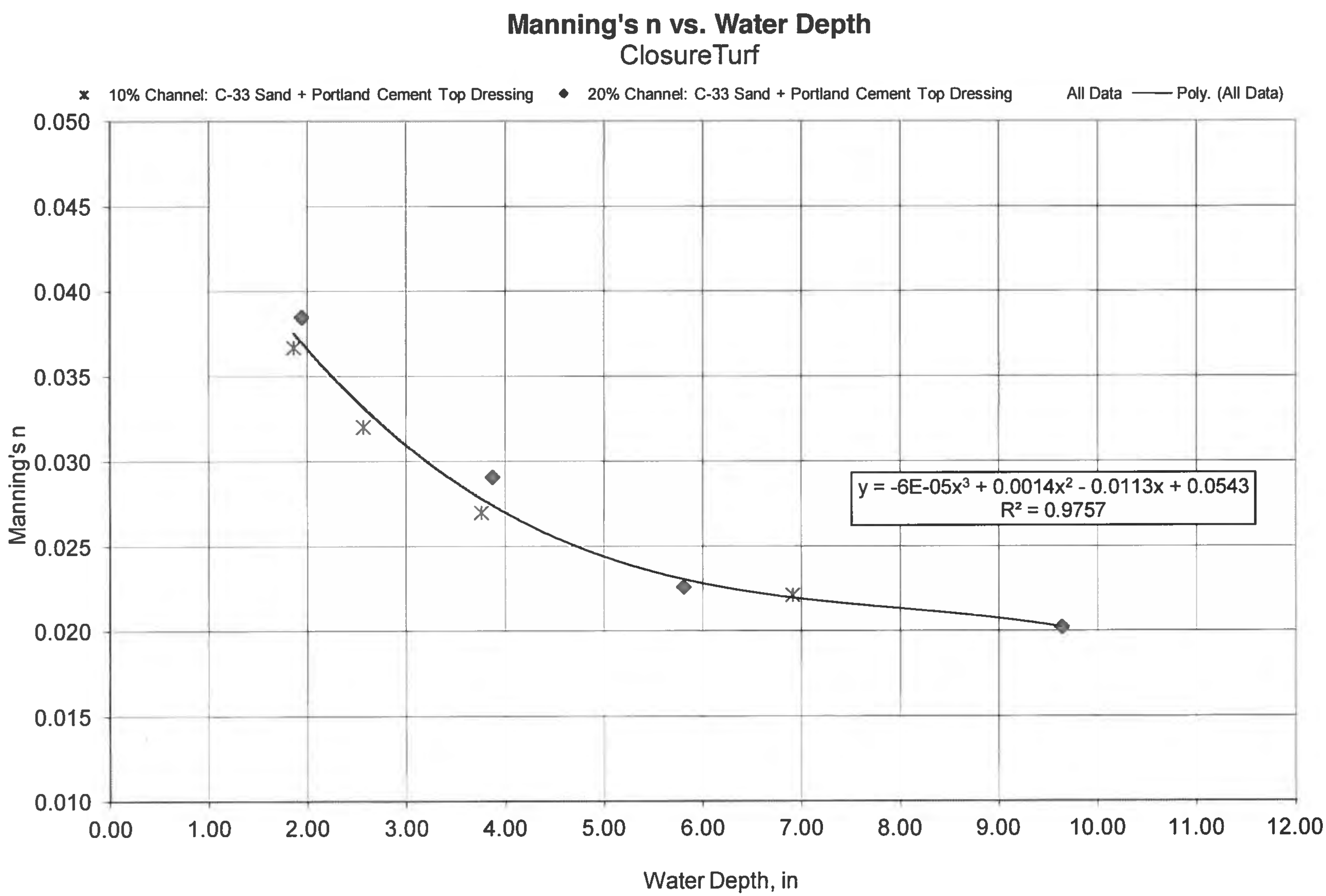

Close-up After Highest Shear

CJS 8/17/15
Quality Review / Date

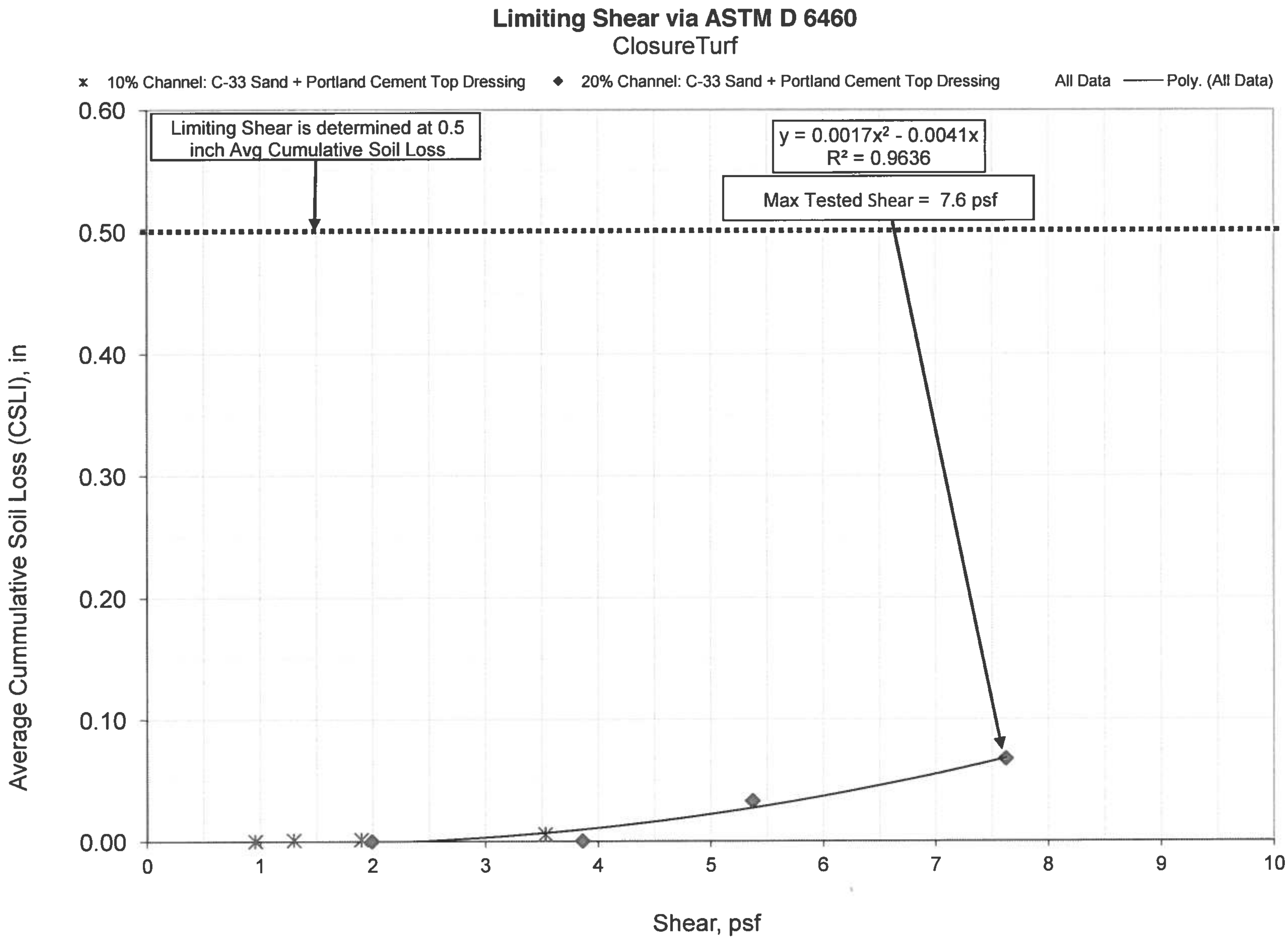
APPENDIX - DATA

Date:	7/20/15	RECP:	Closure Turf			Lot #:				Anchorage:		Sand & Cement					
Slope:	10%	Start Time:	2:06 PM	Channel #	Shear #	Start Time:	3:11 PM	Channel #	Shear #	Start Time:	3:53 PM	Channel #	Shear #	Start Time:	4:36 PM	Channel #	Shear #
Width:	2	End Time:	2:36 PM	1	1	End Time:	3:41 PM	1	2	End Time:	4:23 PM	1	3	End Time:	5:06 PM	1	4
Cross-Section Measurements		Measured Volumetric Flow, cfs:			1.14	Measured Volumetric Flow, cfs:			2.21	Measured Volumetric Flow, cfs:			4.96	Measured Volumetric Flow, cfs:			16.78
1	To original Surface Elev, cm	67.5	67.2	67.4	Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.5	67.2	67.4	67.4	67.5	67.2	67.4	67.4	67.5	67.2	67.4	67.4	67.5	67.2	67.4	67.4
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		3.6		0.0		4.9		0.0		7.7		0.0		13.6
	Distance to Water Surface, cm		62.5		62.5		60.5		60.5		57.5		57.5		48.5		48.5
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.14	1.92			2.21	2.70			4.96	3.88			16.78	7.43		
2	To original Surface Elev, cm	67.2	67.0	66.6	Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.2	67.0	66.6	66.9	67.2	67.0	66.6	66.9	67.2	67.0	66.6	66.9	67.2	67.0	66.6	66.9
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		3.5		0.0		5.1		0.0		7.8		0.0		13.7
	Distance to Water Surface, cm		62.0		62.0		60.3		60.3		57.2		57.2		48.3		48.3
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.14	1.94			2.21	2.61			4.96	3.83			16.78	7.34		
3	To original Surface Elev, cm	67.5	67.7	67.2	Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.5	67.7	67.2	67.5	67.5	67.7	67.2	67.5	67.5	67.7	67.2	67.5	67.5	67.7	67.2	67.5
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		3.6		0.0		5.1		0.0		8.0		0.0		13.8
	Distance to Water Surface, cm		62.7		62.7		60.9		60.9		58.0		58.0		49.0		49.0
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.14	1.88			2.21	2.59			4.96	3.73			16.78	7.27		
4	To original Surface Elev, cm	67.6	67.6	67.5	Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.6	67.6	67.5	67.6	67.6	67.6	67.5	67.6	67.6	67.6	67.5	67.6	67.6	67.7	67.5	67.6
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	0.00	-0.01
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	0.00	-0.01
	Velocity, ft/s		0.0		3.6		0.0		5.1		0.0		7.9		0.0		14.1
	Distance to Water Surface, cm		62.8		62.8		61.0		61.0		58.0		58.0		49.5		49.5
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.14	1.88			2.21	2.59			4.96	3.77			16.78	7.13		
5	To original Surface Elev, cm	67.0	67.1	67.0	Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.0	67.1	67.0	67.0	67.0	67.1	67.0	67.0	67.0	67.1	67.0	67.0	67.0	67.1	67.1	67.1
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.01
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.01
	Velocity, ft/s		0.0		3.7		0.0		5.2		0.0		8.0		0.0		14.2
	Distance to Water Surface, cm		62.3		62.3		60.5		60.5		57.6		57.6		49.0		49.0
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.14	1.86			2.21	2.57			4.96	3.71			16.78	7.11		
6	To original Surface Elev, cm	67.3	67.7	67.2	Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.3	67.7	67.2	67.4	67.3	67.7	67.2	67.4	67.3	67.7	67.2	67.4	67.3	67.8	67.2	67.4
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	0.00	-0.01
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	0.00	-0.01
	Velocity, ft/s		0.0		3.8		0.0		5.0		0.0		7.9		0.0		14.3
	Distance to Water Surface, cm		62.8		62.8		60.7		60.7		57.8		57.8		49.5		49.5
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.14	1.81			2.21	2.64			4.96	3.78			16.78	7.06		
7	To original Surface Elev, cm	67.0	67.4	67.0	Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.0	67.4	67.0	67.1	67.0	67.4	67.0	67.1	67.0	67.4	67.0	67.1	67.0	67.4	67.0	67.1
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		3.7		0.0		5.2		0.0		7.9		0.0		14.6
	Distance to Water Surface, cm		62.5		62.5		60.6		60.6		57.6		57.6		49.6		49.6
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.14	1.82			2.21	2.57			4.96	3.75			16.78	6.90		
8	To original Surface Elev, cm	67.0	66.8	67.0	Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.0	66.8	67.0	66.9	67.0	66.8	67.0	66.9	67.0	66.8	67.0	66.9	67.0	66.9	67.1	67.0
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.02
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.02
	Velocity, ft/s		0.0		3.7		0.0		5.2		0.0		8.0		0.0		14.6
	Distance to Water Surface, cm		62.2		62.2		60.5		60.5		57.5		57.5		49.5		49.5
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.14	1.86			2.21	2.53			4.96	3.71			16.78	6.89		
9	To original Surface Elev, cm	67.2	67.5	67.1	Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.2	67.5	67.1	67.3	67.2	67.5	67.2	67.3	67.2	67.5	67.2	67.3	67.2	67.5	67.2	67.3
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.01	0.00	0.00	-0.04	-0.01	0.00	0.00	-0.04	-0.01
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.01	0.00	0.00	-0.04	-0.01	0.00	0.00	-0.04	-0.01
	Velocity, ft/s		0.0		3.6		0.0		5.2		0.0		7.9		0.0		14.4
	Distance to Water Surface, cm		62.5		62.5		60.8		60.8		57.7		57.7		49.6		49.6
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.14	1.88			2.21	2.56			4.96	3.78			16.78	6.97		
10	To original Surface Elev, cm	67.0	67.2	66.8	Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.0	67.2	66.8	67.0	67.0	67.2	66.8	67.0	67.0	67.2	66.8	67.0	67.0	67.3	66.9	67.1
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.02
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.02
	Velocity, ft/s		0.0		3.8		0.0		5.4		0.0		8.0		0.0		14.6
	Distance to Water Surface, cm		62.4		62.4		60.8		60.8		57.5		57.5		49.5		49.5
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.14	1.81			2.21	2.44			4.96	3.74			16.78	6.92		
11	To original Surface Elev, cm	67.1	66.7	66.0	Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.1	66.7	66.0	66.6	67.1	66.7	66.0	66.6	67.1	66.7	66.1	66.6	67.1	66.7	66.1	66.6
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.01	0.00	0.00	-0.04	-0.01
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.01	0.00	0.00	-0.04	-0.01
	Velocity, ft/s		0.0		3.9		0.0		5.5		0.0		8.2		0.0		14.7
	Distance to Water Surface, cm		62.3		62.1		60.5		60.5		57.9		57.4		49.2		49.2
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.14	1.77			2.21	2.40			4.96	3.64			16.78	6.86		

Date:	7/31/15	RECP:	Closure Turf			Lot #:	C33 Sand + Cement			Anchorage:											
Slope:	20%	Start Time:	9:12 AM	Channel #	Shear #	Start Time:		Channel #	Shear #	Start Time:		Channel #	Shear #	Start Time:		Channel #	Shear #	Start Time:		Channel #	Shear #
Width:	2	End Time:	9:42 AM	1	1	End Time:		1	2	End Time:		1	3	End Time:		1	4	End Time:		1	5
Cross-Section Measurements		Measured Volumetric Flow, cfs:			1.66	Measured Volumetric Flow, cfs:			6.86	Measured Volumetric Flow, cfs:			16.72	Measured Volumetric Flow, cfs:			-40.27	Measured Volumetric Flow, cfs:			#DIV/0!
1	To original Surface Elev, cm	67.2	67.1	66.7	Avg.				Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.2	67.1	66.7	67.0	67.2	67.1	66.7	67.0	67.3	67.2	66.8	67.1	67.4	67.3	66.9	67.2				#DIV/0!
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	26.46	26.42	26.26	21.98
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		5.1		0.0		10.3		0.0		16.9		0.0		24.4				#DIV/0!
	Distance to Water Surface, cm		62.0		62.0		56.8		56.8		52.0		52.0		42.0		42.0				#DIV/0!
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.66	1.97			6.86	4.02			16.72	5.94			-40.27	9.92			#DIV/0!	#DIV/0!		
2	To original Surface Elev, cm	67.1	67.6	66.9	Avg.				Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.1	67.6	66.9	67.2	67.1	67.6	66.9	67.2	67.2	67.7	67.0	67.3	67.3	67.8	67.2	67.4				#DIV/0!
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.12	-0.08	26.42	26.61	26.34	22.02
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.12	-0.08	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		5.0		0.0		10.4		0.0		17.0		0.0		24.6				#DIV/0!
	Distance to Water Surface, cm		62.1		62.1		57.1		57.1		52.3		52.3		42.5		42.5				#DIV/0!
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.66	2.01			6.86	3.98			16.72	5.91			-40.27	9.82			#DIV/0!	#DIV/0!		
3	To original Surface Elev, cm	67.1	66.9	66.8	Avg.				Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.1	66.9	66.8	66.9	67.1	66.9	66.8	66.9	67.2	67.0	66.9	67.0	67.3	67.1	67.0	67.1				#DIV/0!
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	26.42	26.34	26.30	21.96
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		5.1		0.0		10.5		0.0		17.1		0.0		24.8				#DIV/0!
	Distance to Water Surface, cm		62.0		62.0		57.0		57.0		52.1		52.1		42.4		42.4				#DIV/0!
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.66	1.94			6.86	3.91			16.72	5.88			-40.27	9.74			#DIV/0!	#DIV/0!		
4	To original Surface Elev, cm	67.0	67.0	66.5	Avg.				Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.0	67.0	66.5	66.8	67.0	67.0	66.5	66.8	67.1	67.1	66.6	66.9	67.2	67.2	66.7	67.0				#DIV/0!
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	26.38	26.38	26.18	21.92
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		5.2		0.0		10.6		0.0		17.1		0.0		24.9				#DIV/0!
	Distance to Water Surface, cm		62.0		62.0		57.0		57.0		52.0		52.0		42.4		42.4				#DIV/0!
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.66	1.90			6.86	3.87			16.72	5.88			-40.27	9.70			#DIV/0!	#DIV/0!		
5	To original Surface Elev, cm	67.6	67.1	66.3	Avg.				Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.6	67.1	66.3	67.0	67.6	67.1	66.3	67.0	67.7	67.2	66.4	67.1	67.8	67.3	66.5	67.2				#DIV/0!
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	26.61	26.42	26.10	21.98
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		5.0		0.0		10.7		0.0		17.2		0.0		24.8				#DIV/0!
	Distance to Water Surface, cm		61.9		61.9		57.2		57.2		52.3		52.3		42.5		42.5				#DIV/0!
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.66	2.01			6.86	3.86			16.72	5.83			-40.27	9.72			#DIV/0!	#DIV/0!		
6	To original Surface Elev, cm	67.0	67.0	66.7	Avg.				Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.0	67.0	66.7	66.9	67.0	67.0	66.7	66.9	67.1	67.1	66.8	67.0	67.2	67.2	66.9	67.1				#DIV/0!
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	26.38	26.38	26.26	21.94
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		5.0		0.0		10.8		0.0		17.3		0.0		25.3				#DIV/0!
	Distance to Water Surface, cm		61.8		61.8		57.2		57.2		52.3		52.3		42.8		42.8				#DIV/0!
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.66	2.01			6.86	3.82			16.72	5.79			-40.27	9.57			#DIV/0!	#DIV/0!		
7	To original Surface Elev, cm	67.5	67.5	67.0	Avg.				Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.5	67.5	67.0	67.3	67.5	67.5	67.0	67.3	67.6	67.6	67.1	67.4	67.7	67.7	67.2	67.5				#DIV/0!
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	26.57	26.57	26.38	22.08
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		5.0		0.0		10.6		0.0		17.4		0.0		25.0				#DIV/0!
	Distance to Water Surface, cm		62.3		62.3		57.5		57.5		52.8		52.8		43.0		43.0				#DIV/0!
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.66	1.98			6.86	3.87			16.72	5.76			-40.27	9.66			#DIV/0!	#DIV/0!		
8	To original Surface Elev, cm	67.2	67.5	66.6	Avg.				Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	67.2	67.5	66.6	67.1	67.2	67.5	66.6	67.1	67.3	67.6	66.7	67.2	67.4	67.7	66.8	67.3				#DIV/0!
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	26.46	26.57	26.22	21.99
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		5.0		0.0		10.7		0.0		17.2		0.0		25.3				#DIV/0!
	Distance to Water Surface, cm		62.0		62.0		57.3		57.3		52.4		52.4		43.0		43.0				#DIV/0!
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.66	2.01			6.86	3.86			16.72	5.83			-40.27	9.57			#DIV/0!	#DIV/0!		
9	To original Surface Elev, cm	66.6	66.8	66.7	Avg.				Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	66.6	66.8	66.7	66.7	66.6	66.8	66.7	66.7	66.7	66.9	66.8	66.8	66.8	67.0	66.9	66.9				#DIV/0!
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	26.22	26.30	26.26	21.88
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		5.4		0.0		10.8		0.0		17.6		0.0		25.5				#DIV/0!
	Distance to Water Surface, cm		62.0		62.0		57.0		57.0		52.3		52.3		42.8		42.8				#DIV/0!
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.66	1.85			6.86	3.82			16.72	5.71			-40.27	9.49			#DIV/0!	#DIV/0!		
10	To original Surface Elev, cm	66.6	67.0	66.6	Avg.				Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	66.6	67.0	66.6	66.7	66.6	67.0	66.6	66.7	66.7	67.1	66.7	66.8	66.8	67.2	66.8	66.9				#DIV/0!
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	26.22	26.38	26.22	21.88
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		5.4		0.0		10.9		0.0		17.5		0.0		25.6				#DIV/0!
	Distance to Water Surface, cm		62.1		62.1		57.1		57.1		52.3		52.3		43.0		43.0				#DIV/0!
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.66	1.82			6.86	3.79			16.72	5.72			-40.27	9.42			#DIV/0!	#DIV/0!		
11	To original Surface Elev, cm	66.6	66.5	66.7	Avg.				Avg.				Avg.				Avg.				Avg.
	To eroded Surface Elev, cm	66.6	66.5	66.7	66.6	66.6	66.5	66.7	66.6	66.7	66.6	66.8	66.7	66.8	66.7	66.9	66.8				#DIV/0!
	Loss/Gain, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	26.22	26.18	26.26	21.86
	CSLI, sq.in./in. width	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.04	-0.03	-0.08	-0.08	-0.08	-0.07	0.00	0.00	0.00	0.00
	Velocity, ft/s		0.0		5.5		0.0		10.9		0.0		17.9		0.0		25.8				#DIV/0!
	Distance to Water Surface, cm		62.0		62.0		57.0		57.0		52.5		52.5		43.0		43.0				#DIV/0!
	Calculations	Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in			Flow, cfs	Depth, in		
		1.66	1.81			6.86	3.78			16.72	5.59			-40.27	9.37			#DIV/0!	#DIV/0!		



Manning's n vs. Water Depth
ClosureTurf
10% Channel: C-33 Sand + Portland Cement Top Dressing
20% Channel: C-33 Sand + Portland Cement Top Dressing
All Data
Poly. (All Data)
y = -6E-05x³ + 0.0014x² - 0.0113x + 0.0543
R² = 0.9757
Manning's n
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
Water Depth, in


Limiting Shear via ASTM D 6460
ClosureTurf
10% Channel: C-33 Sand + Portland Cement Top Dressing
20% Channel: C-33 Sand + Portland Cement Top Dressing
All Data
Poly. (All Data)
Limiting Shear is determined at 0.5 inch Avg Cumulative Soil Loss
y = 0.0017x² - 0.0041x
R² = 0.9636
Max Tested Shear = 7.6 psf
Average Cummulative Soil Loss (CSLI), in
Shear, psf
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
1
2
3
4
5
6
7
8
9
10

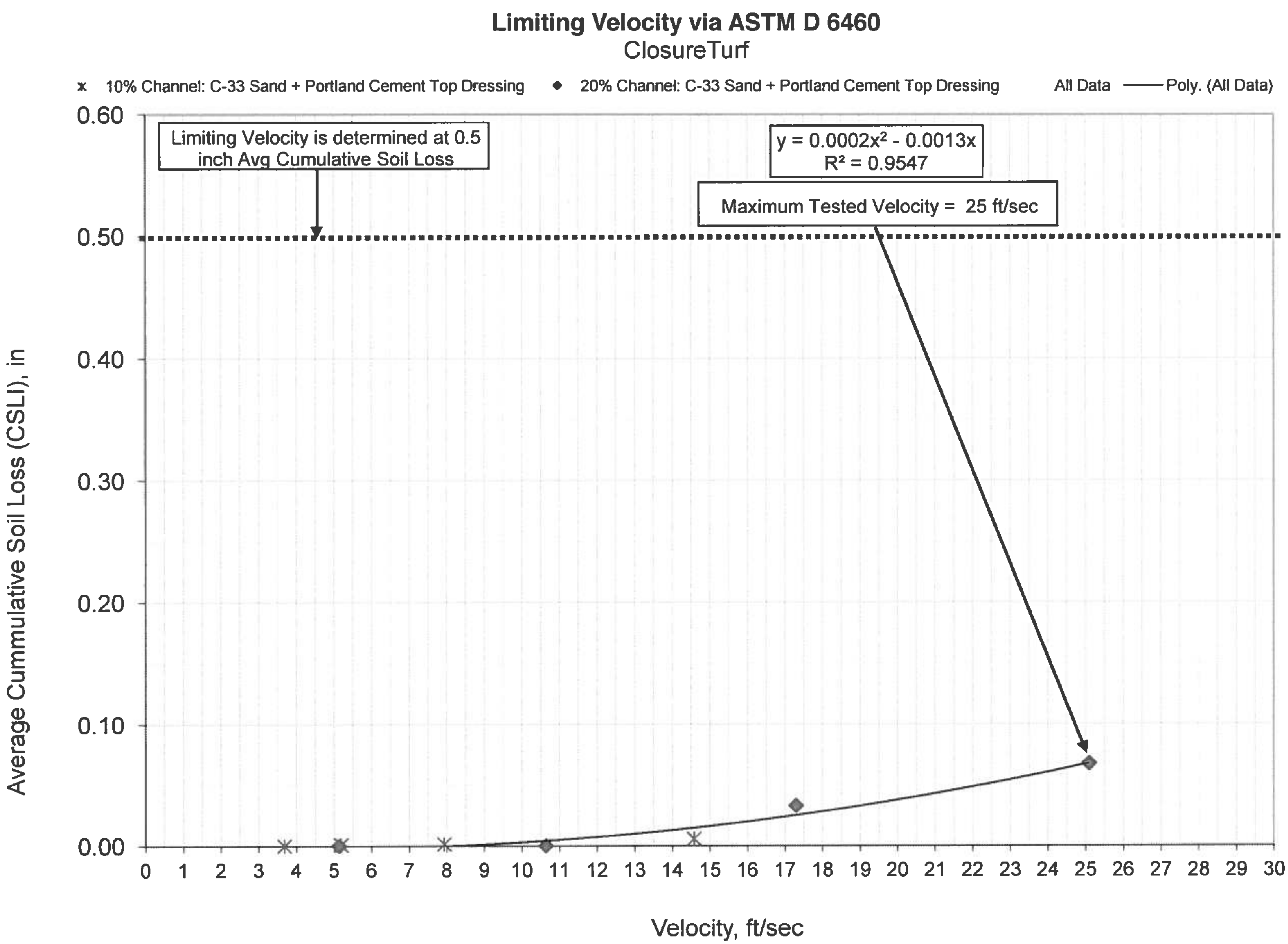

Limiting Velocity via ASTM D 6460
ClosureTurf
10% Channel: C-33 Sand + Portland Cement Top Dressing
20% Channel: C-33 Sand + Portland Cement Top Dressing
All Data
Poly. (All Data)
Limiting Velocity is determined at 0.5 inch Avg Cumulative Soil Loss
y = 0.0002x² - 0.0013x
R² = 0.9547
Maximum Tested Velocity = 25 ft/sec
Average Cummulative Soil Loss (CSLI), in
Velocity, ft/sec
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

EXHIBIT 21

SGI TESTING SERVICES

A GEORGIA LIMITED LIABILITY COMPANY

27 June 2010

Mr. Jose Urrutia
Closure Turf, LLC
3005 Breckinridge Blvd., Suite 240
Duluth, Georgia 3096

Subject: Laboratory Test Results Transmittal
Interface Direct Shear Testing
Closure Turf Cover System

Dear Mr. Urrutia,

SGI Testing Services, LLC (SGI) is pleased to present the attached test results for the above-mentioned project. The note section below addresses sample preparation, sample disposal and a disclosure statement.

SGI appreciates the opportunity to provide laboratory testing services to Closure Turf, LLC. Should you have any questions regarding the attached document(s), or if you require additional information, please do not hesitate to contact the undersigned.

Sincerely,

Zehong Yuan, Ph.D., P.E.
Laboratory Manager

Attachments

NOTES:
(1) Unless otherwise noted in the test results the sample(s)/specimen(s) were prepared in accordance with the applicable test standards or generally accepted sampling procedures.
(2) Contaminated/chemical samples and all related laboratory generated waste (i.e., test liquids, PPE, absorbents, etc.) will be returned to the client or designated representative(s), at the client's cost, within 60 days following the completion of the testing program, unless special arrangements for proper disposal are made with SGI.
(3) Materials that are not contaminated will be discarded after test specimens and archived specimens are obtained. Archived specimens will be discarded 30 days after the completion of the testing program, unless long-term storage arrangements are specifically made with SGI.
(4) The reported results apply only to the materials and test conditions used in the laboratory testing program. The results do not necessarily apply to other materials or test conditions. The test results should not be used in engineering analysis unless the test conditions model the anticipated field conditions. The testing was performed in accordance with general engineering testing standards and requirements. The reported results are submitted for the exclusive use of the client to whom they are addressed.

SGI10007.REPORT.2010.06

MAIL TO: SGI TESTING SERVICES, LLC
P.O. BOX 2427
LILBURN, GA 30048-2427

FACILITY LOCATION
4405 INTERNATIONAL BLVD., SUITE B-117
NORCROSS, GA 30093

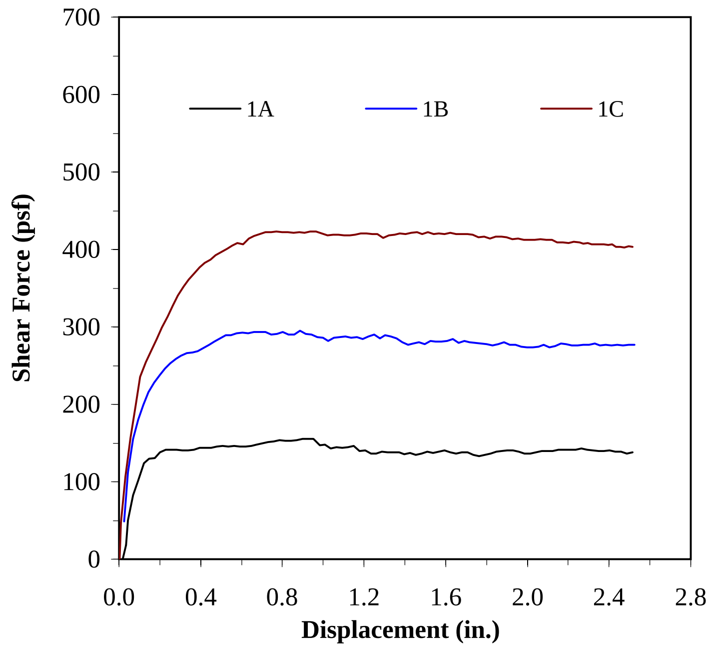
WEB SITE: WWW.INTERACTIONSPECIALISTS.COM
PHONE: 770.931.8222 FAX: 770.931.8240

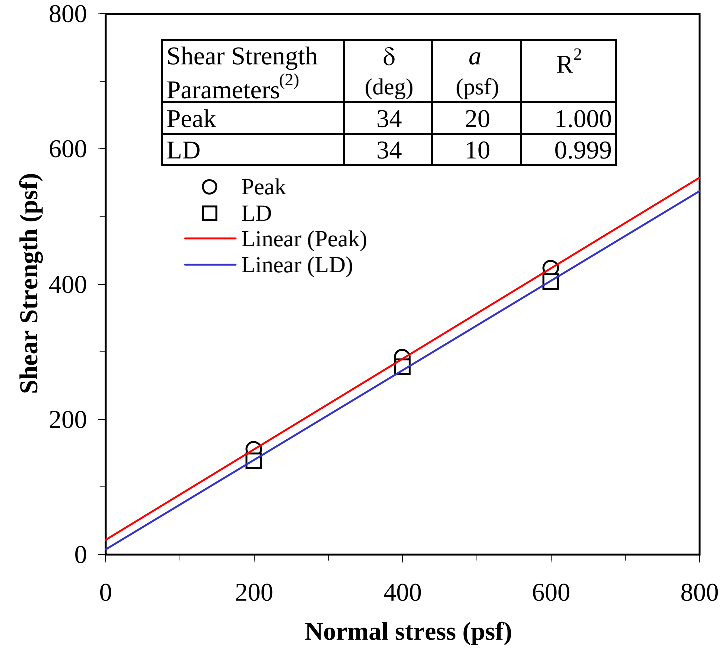
ATTACHMENT A

TEST RESULTS

CLOSURE TURF LLC -LANDFILL COVER SYSTEM
INTERFACE DIRECT SHEAR TESTING (ASTM D 5321)

Upper Shear Box: Concrete sand nominally compacted/
Artificial grass with grass side (green yarns) side up
Lower Shear Box: Concrete sand





Test No.	Shear Box Size (in. x in.)	Normal Stress (psf)	Shear Rate (in./min)	Soaking		Consolidation		Concrete Sand			Upper Soil			GCL		Shear Strengths		Failure Mode
				Stress (psf)	Time (hour)	Stress (psf)	Time (hour)	γ_d (pcf)	ω_i (%)	ω_f (%)	γ_d (pcf)	ω_i (%)	ω_f (%)	ω_i (%)	ω_f (%)	τ_P (psf)	τ_{LD} (psf)	
1A	12 x 12	200	0.04	200	24	-	-	-	-	-	-	-	-	-	-	155	138	(1)
1B	12 x 12	400	0.04	400	24	-	-	-	-	-	-	-	-	-	-	292	277	(1)
1C	12 x 12	600	0.04	600	24	-	-	-	-	-	-	-	-	-	-	423	403	(1)

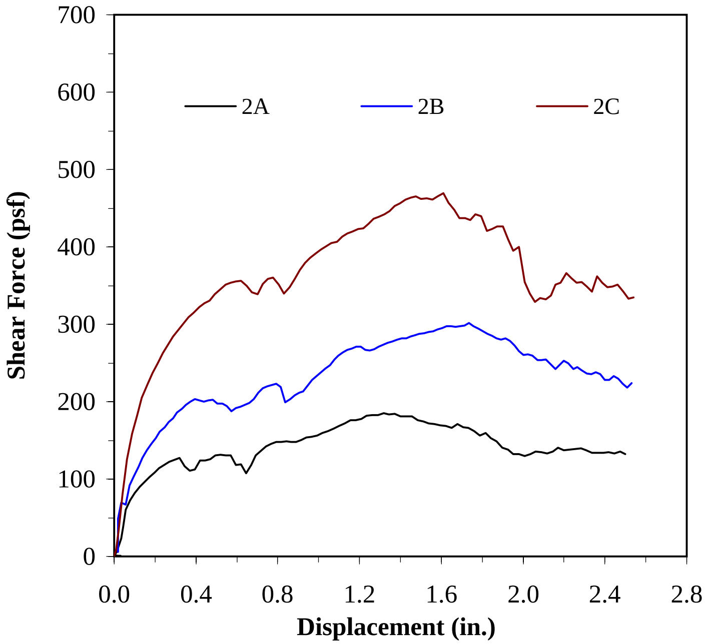
NOTES:
(1) Sliding (i.e., shear failure) occurred at the interface between the upper concrete sand and grass side of the artificial grass.
(2) The reported total-stress parameters of friction angle and adhesion were determined from a best-fit line drawn through the test data. Caution should be exercised in using these strength parameters for applications involving normal stresses outside the range of the stresses covered by the test series. The large-displacement (LD) shear strength was calculated using the shear fo measured at the end of the test.

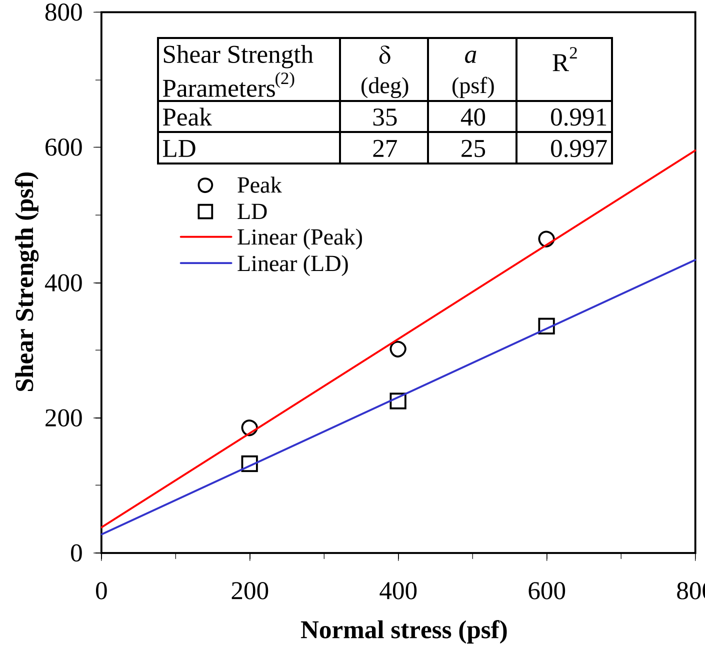
SGI TESTING SERVICES, LLC

DATE OF TEST:	4/27/2010
FIGURE NO.	C-1
PROJECT NO.	SGI10007
DOCUMENT NO.	
FILE NO.	

CLOSURE TURF LLC -LANDFILL COVER SYSTEM
INTERFACE DIRECT SHEAR TESTING (ASTM D 5321)

Upper Shear Box: Concrete sand nominally compacted
Artificial grass with grass side (green yarns) up/
Agru 50 mil LLDPE Super Gripnet geomembrane with studs side up/
Lower Shear Box: Concrete sand





Test No.	Shear Box Size (in. x in.)	Normal Stress (psf)	Shear Rate (in./min)	Soaking		Consolidation		Concrete Sand			Upper Soil			GCL		Shear Strengths		Failure Mode
				Stress (psf)	Time (hour)	Stress (psf)	Time (hour)	γ_d (pcf)	ω_i (%)	ω_f (%)	γ_d (pcf)	ω_i (%)	ω_f (%)	ω_i (%)	ω_f (%)	τ_P (psf)	τ_{LD} (psf)	
2A	12 x 12	200	0.04	200	24	-	-	-	-	-	-	-	-	-	-	185	132	(1)
2B	12 x 12	400	0.04	400	24	-	-	-	-	-	-	-	-	-	-	302	224	(1)
2C	12 x 12	600	0.04	600	24	-	-	-	-	-	-	-	-	-	-	464	335	(1)

NOTES:
(1) Sliding (i.e., shear failure) occurred at the interface between the geotextile of the artificial grass and studs side of the geomembrane.
(2) The reported total-stress parameters of friction angle and adhesion were determined from a best-fit line drawn through the test data. Caution should be exercised in using these strength parameters for applications involving normal stresses outside the range of the stresses covered by the test series. The large-displacement (LD) shear strength was calculated using the shear fo measured at the end of the test.

SGI TESTING SERVICES, LLC

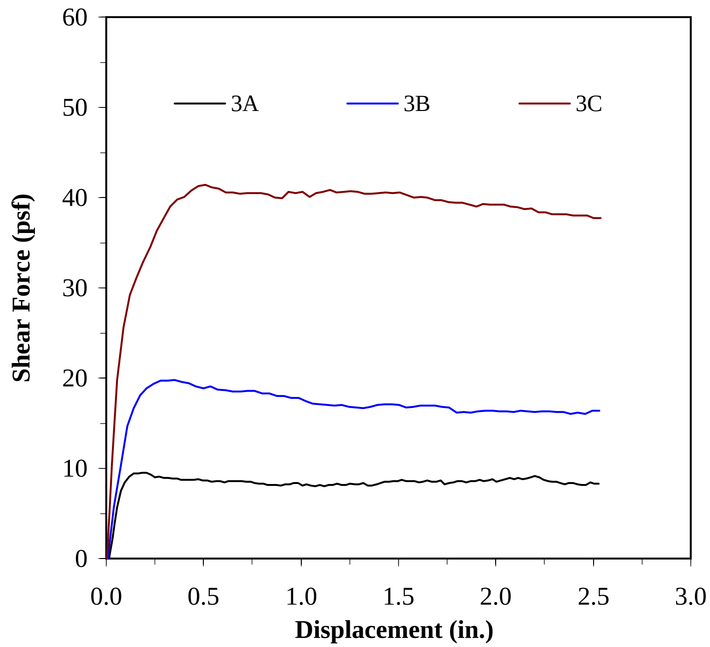
DATE OF TEST:	4/27/2010
FIGURE NO.	C-2
PROJECT NO.	SGI10007
DOCUMENT NO.	
FILE NO.	

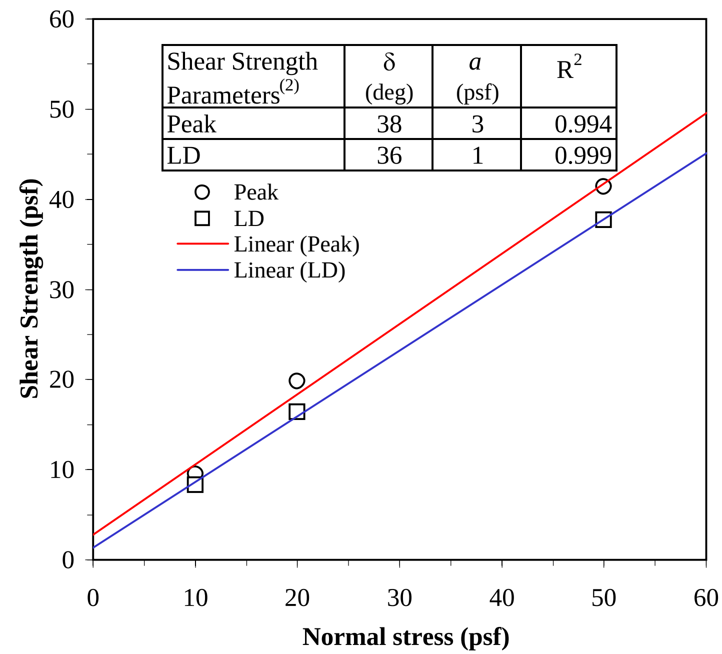
ATTACHMENT B

TEST RESULTS (LOW NORMAL STRESS)

CLOSURETURF LLC -LANDFILL COVER SYSTEM
INTERFACE DIRECT SHEAR TESTING (ASTM D 5321)

Upper Shear Box: Concrete sand nominally compacted/
Artificial grass with grass side (green yarns) side up
Lower Shear Box: Concrete sand





Test No.	Shear Box Size (in. x in.)	Normal Stress (psf)	Shear Rate (in./min)	Soaking Stress (psf)	Soaking Time (hour)	Consolidation Stress (psf)	Consolidation Time (hour)	Lower Soil γ_d (pcf)	Lower Soil ω_i (%)	Lower Soil ω_f (%)	Upper Soil γ_d (pcf)	Upper Soil ω_i (%)	Upper Soil ω_f (%)	GCL ω_i (%)	GCL ω_f (%)	Shear Strengths τ_P (psf)	Shear Strengths τ_{LD} (psf)	Failure Mode
3A	12 x 12	10	0.04	10	24	-	-	-	-	-	-	-	-	-	-	10	8	(1)
3B	12 x 12	20	0.04	20	24	-	-	-	-	-	-	-	-	-	-	20	16	(1)
3C	12 x 12	50	0.04	50	24	-	-	-	-	-	-	-	-	-	-	41	38	(1)

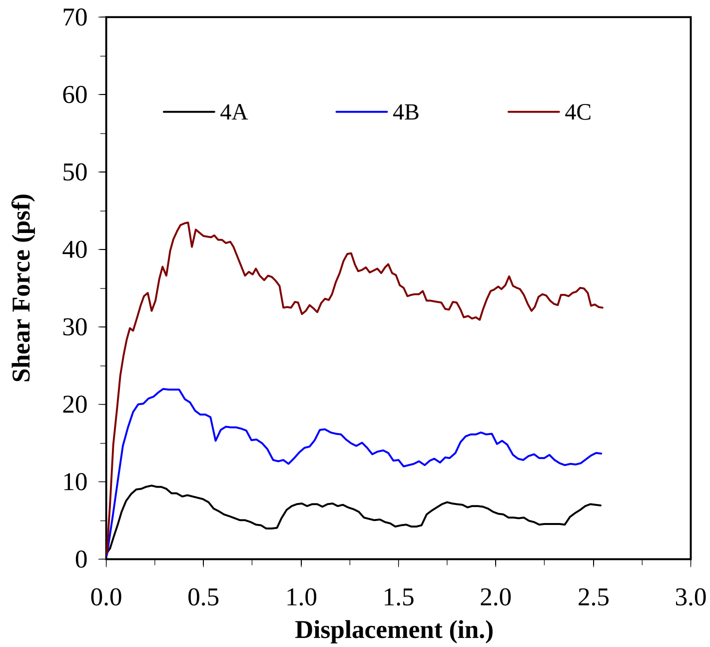
NOTES:
(1) Sliding (i.e., shear failure) occurred at the interface between the upper concrete sand and grass side of the artificial grass.
(2) The reported total-stress parameters of friction angle and adhesion were determined from a best-fit line drawn through the test data. Caution should be exercised in using these strength parameters for applications involving normal stresses outside the range of the stresses covered by the test series. The large-displacement (LD) shear strength was calculated using the shear force measured at the end of the test.

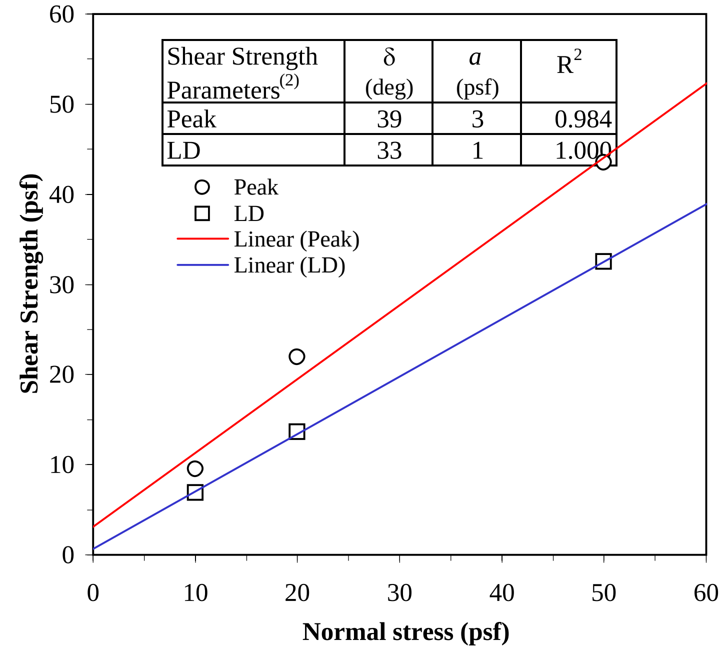
DATE OF TEST:	5/15/2010
FIGURE NO.	C-3
PROJECT NO.	SGI10007
DOCUMENT NO.	
FILE NO.	

SGI TESTING SERVICES, LLC

CLOSURETURF LLC -LANDFILL COVER SYSTEM
INTERFACE DIRECT SHEAR TESTING (ASTM D 5321)

Upper Shear Box: Concrete sand nominally compacted
Artificial grass with grass side (green yarns) up/
Agru 50 mil LLDPE Super Gripnet geomembrane with studs side up/
Lower Shear Box: Concrete sand





Test No.	Shear Box Size (in. x in.)	Normal Stress (psf)	Shear Rate (in./min)	Soaking		Consolidation		Lower Soil			Upper Soil			GCL		Shear Strengths		Failure Mode
				Stress (psf)	Time (hour)	Stress (psf)	Time (hour)	γ_d (pcf)	ω_i (%)	ω_f (%)	γ_d (pcf)	ω_i (%)	ω_f (%)	ω_i (%)	ω_f (%)	τ_P (psf)	τ_{LD} (psf)	
4A	12 x 12	10	0.04	10	24	-	-	-	-	-	-	-	-	-	-	10	7	(1)
4B	12 x 12	20	0.04	20	24	-	-	-	-	-	-	-	-	-	-	22	14	(1)
4C	12 x 12	50	0.04	50	24	-	-	-	-	-	-	-	-	-	-	44	33	(1)

NOTES:
(1) Sliding (i.e., shear failure) occurred at the interface between the geotextile of the artificial grass and studs side of the geomembrane.
(2) The reported total-stress parameters of friction angle and adhesion were determined from a best-fit line drawn through the test data. Caution should be exercised in using these strength parameters for applications involving normal stresses outside the range of the stresses covered by the test series. The large-displacement (LD) shear strength was calculated using the shear force measured at the end of the test.

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DATE OF TEST:	5/15/2010
FIGURE NO.	C-4
PROJECT NO.	SGI10007
DOCUMENT NO.	
FILE NO.	

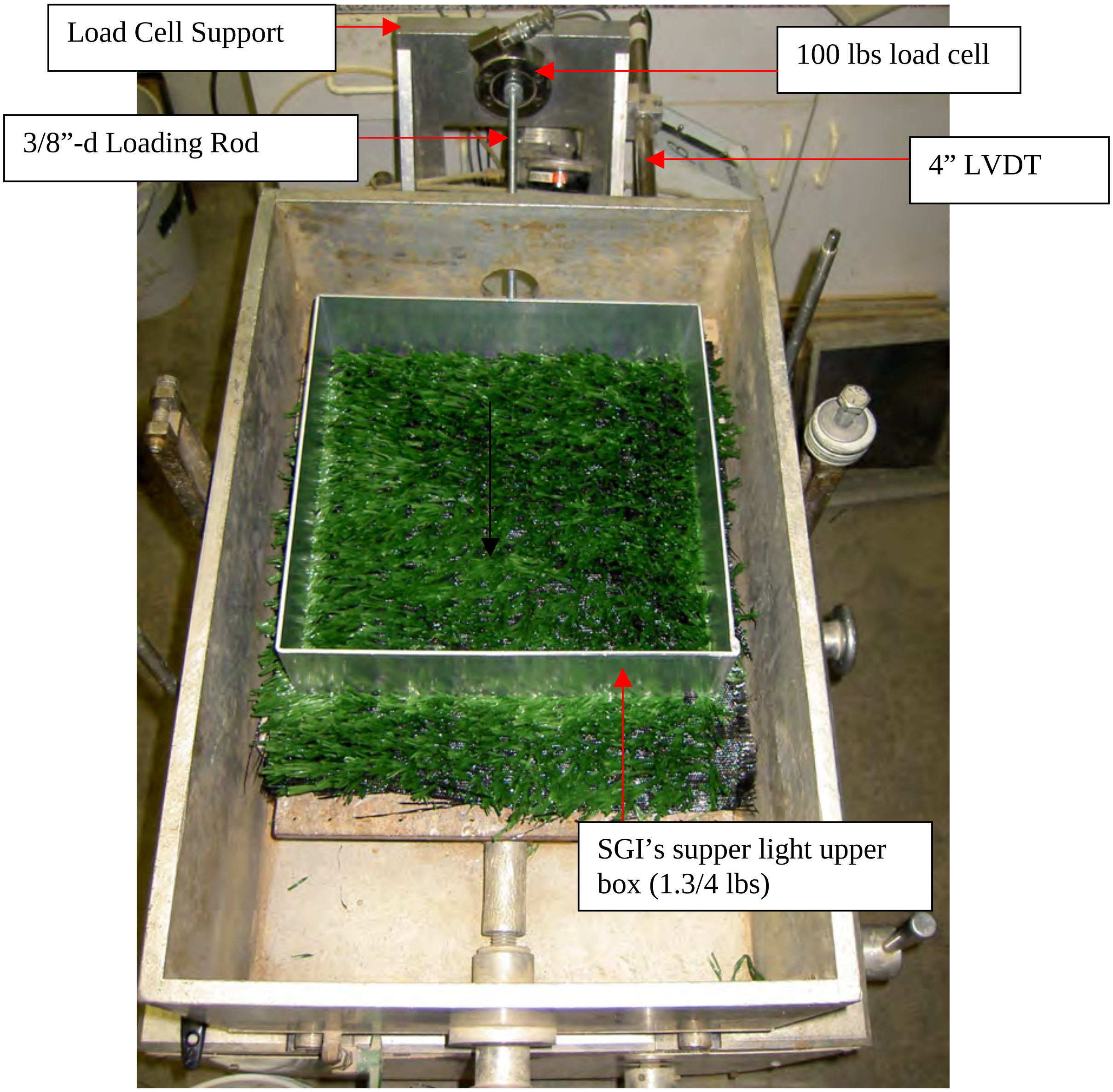

Figure 1. SGI's low pressure interface direct shear test setup.

Figure 2. Sand/grass interface test at a normal stress of 20 psf.