First State Geology

Current information about Delaware's geology, hydrology, and mineral resources

Published twice yearly by the Delaware Geological Survey
University of Delaware

Vol. 22, No. 2 • Summer 2004

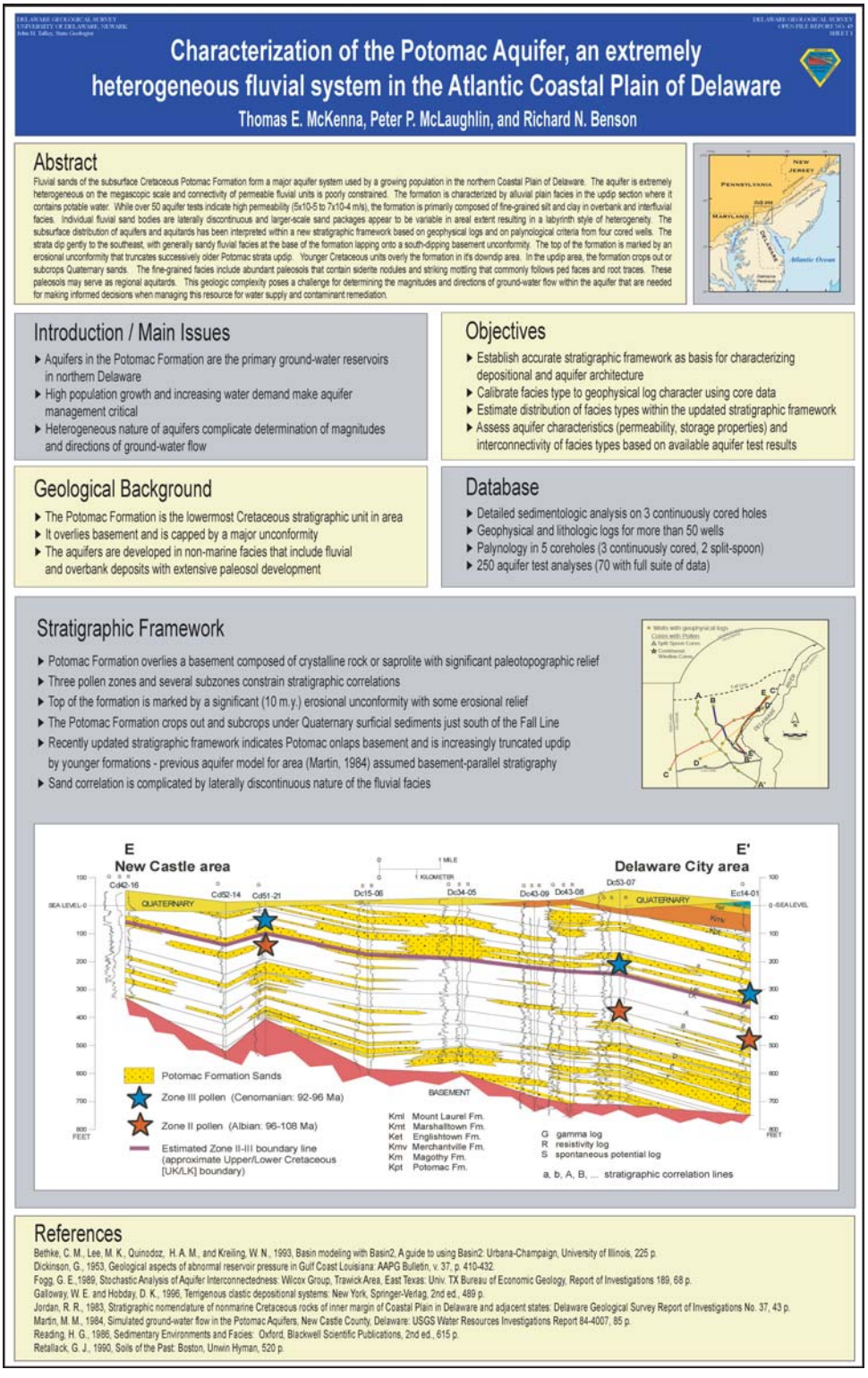
New Report on the Potomac Aquifer in New Castle County

By T. E. McKenna

As part of a continuing investigation of ground water in the Potomac Formation in New Castle County, DGS has released a new publication describing the systematic approach being used to characterize the hydrogeologic properties of the Potomac Formation. Open File Report 45 is entitled "Characterization of the Potomac Aquifer, an extremely heterogeneous fluvial system in the Atlantic Coastal Plain of Delaware," and presents the results of research by Thomas E. McKenna, Peter P. McLaughlin, Jr., and Richard N. Benson. This publication introduces a conceptual hydrogeologic model for the Potomac aquifer system based on a new stratigraphic framework as discussed in the Winter 2002 and Summer 2003 issues of *First State Geology*. The publication is in a poster format and was presented at the Society for Sedimentary Geology (SEPM) Research Conference on Ancient and Modern Coastal Plain Depositional Environments: Aquifer Heterogeneity and Environmental Implications, March 24th - 27th, 2002 in Charleston, South Carolina.

The Potomac Formation hosts an extremely important aquifer that is used as a source of drinking water by a growing population in New Castle County. At the same time, the aquifer is vulnerable to contamination from industrial, agricultural, and domestic sources. Successfully managing this resource requires estimates of the magnitudes and directions of ground-water flow and contaminant transport. These estimates rely on our knowledge and conceptualization of the complex distribution and connectivity of aquifers in the formation that can be difficult to map and characterize.

In New Castle County, sands in the Potomac Formation were deposited during middle Cretaceous time (approximately 120 million to 100 million years ago) as part of a coastal plain river system. The formation contains many aquifer-quality sands but it is primarily composed of fine-grained silt and clay deposited in the floodplains of the rivers.



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Dickinson, G., 1953, Geological aspects of abnormal reservoir pressure in Gulf Coast Louisiana: AAPG Bulletin, v. 37, p. 410-432.
Fogg, G. E., 1989, Stochastic Analysis of Aquifer Interconnectedness: Wilcox Group, Trawick Area, East Texas: Univ. TX Bureau of Economic Geology, Report of Investigations 189, 68 p.
Galloway, W. E. and Hobday, D. K., 1996, Terrigenous clastic depositional systems: New York, Springer-Verlag, 2nd ed., 489 p.
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Martin, M. M., 1984, Simulated ground-water flow in the Potomac Aquifers, New Castle County, Delaware: USGS Water Resources Investigations Report 84-4007, 85 p.
Reading, H. G., 1986, Sedimentary Environments and Facies: Oxford, Blackwell Scientific Publications, 2nd ed., 615 p.
Retallack, G. J., 1990, Soils of the Past: Boston, Unwin Hyman, 520 p.

The distribution of sand is complex because individual sand bodies deposited in river channels are laterally discontinuous and the areal extents and locations of larger-scale sand packages are variable between the different stratigraphic layers within the formation. The key difference in the new conceptual model when compared to other existing models of the Potomac aquifer is that the hydrostratigraphy is interpreted in a sequence stratigraphic framework constrained by fossil dating rather than the lithostratigraphic framework more commonly applied to studies of the aquifer. The concepts of sequence stratigraphy have been used successfully by the oil industry for characterizing oil and gas reservoirs.

Sequence stratigraphic and depositional system analyses guide the new interpretations of where sand bodies may be connected and of the locations where aquifers are directly recharged from the overlying water-table aquifer. Several correlation surfaces were established that approximate land surfaces at different times during the Cretaceous. These surfaces bound layers of sediment. Sedimentary facies within a given layer are likely to be genetically related (deposited by related processes at a similar time in a depositional system within the same paleolandscape). This genetic relationship greatly enhances a geologist's ability to correlate aquifer-quality sands because a paleolandscape and depositional system can be visualized to guide the correlations within the layer. Sands in a layer also may be hydraulically connected to sands in an adjacent layer (sands stacked on top of one another), but our working hypothesis is that this situation is less probable than a genetic connection within a layer. In a lithostratigraphic framework, sands are correlated simply by lithology and it is difficult to constrain a correlation across a regional area as the sands in all of the layers in the Potomac Formation have similar mineralogic and textural characteristics.

Five sedimentary facies were identified utilizing continuous cores and geophysical logs to develop conceptual models for a fluvial depositional system and hydrofacies. Amalgamated and thick isolated sands deposited in channels form the major aquifers. Thin sands deposited in crevasse splay and proximal levee environments form minor aquifers and leaky aquitards. Interlaminated sands and silts deposited in distal levee and flood plain environments form leaky aquitards. Silts and clays deposited in the flood plain form aquitards. Most of the fine-grained silts and clays have striking color mottling resulting from weathering associated with soil formation during the Cretaceous. Some of these dense, weathered paleosols (soils formed in a past environment) may serve as regional aquitards.

This new information is an essential component of, and is currently being used by, the U.S. Army Corps of Engineers in a project that involves ground-water modeling of the Potomac aquifer system to determine the amount of water that can be safely withdrawn from the Potomac aquifers while at the same time ensuring adequate water supplies for the future.

Open File Report No. 45 is available as a downloadable product from the DGS Web page at http://www.udel.edu/dgs/publ.html. "Print on demand" copies of publications may be requested by contacting the Survey at (302) 831-2833 or via email at delgeosurvey@udel.edu.

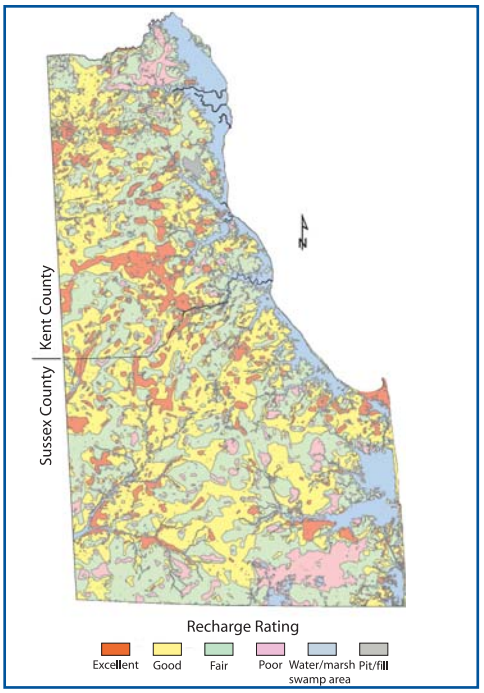
Ground-Water Recharge Mapping Project Completed

By A. S. Andres

The Delaware Geological Survey released Report of Investigations No. 66, a new technical report entitled "Ground-Water Recharge Potential Mapping in Kent and Sussex Counties, Delaware." This report complements two recent DGS Hydrologic Map publications: Hydrologic Map 11, covering Kent County and Hydrologic Map 12, covering Sussex County. The report and maps provide information that will be useful in guiding anticipated growth and economic development, developing and protecting water resources, and cleaning-up of contaminated water supplies. Ground water provides nearly all fresh water for public, domestic, commercial, irrigation, and industrial uses in Delaware south of the Chesapeake and Delaware Canal and about 25 percent north of the Canal.

The report and maps have direct application to the Delaware Source Water Protection program. According to legislation enacted in 2001, counties and municipalities with populations of 2,000 or more shall adopt overlay maps of "excellent recharge areas" and shall adopt regulations governing land use in such areas as part of their 2007 Comprehensive Land Use Plans. Recharge Resource Protection Areas, including excellent recharge areas and wellhead protection areas, have been protected via code in New Castle County since the early 1990s. This project was funded and supported by the Delaware Department of Natural Resources and Environmental Control.

The report documents technical aspects of the recharge-potential mapping program, including analysis of the relationships between recharge potential, and stream flow and hydraulic properties of earth materials. Ground-water flow modeling shows that recharge rates in areas with excellent recharge potential can be two to three times greater than rates in fair and poor recharge areas. Numerical modeling of contaminants shows that greater masses of contaminants move more quickly and affect greater volumes of water under higher recharge potential conditions than under lower recharge potential conditions. This information



can be used to help prioritize and classify contaminated sites for appropriate remedial action.

Report of Investigations No. 66 and Hydrologic Map Nos. 11 and 12 are available in pdf format from the DGS web site at http://www.udel.edu/dgs/ under "Publications." Printed copies of the publications may be requested by contacting the Survey at (302) 831-2833, via email at delgeosurvey@udel.edu, or by visiting the DGS office at the University of Delaware.

Map Conversion Project Completed

By T. E. McKenna

DGS has continually developed and maintained repositories of samples, data, maps, and reports that are the essential building blocks for geologic and hydrologic research and water resource, mineral, and energy exploration. These repositories are often "mined" by DGS staff for research and to fulfill requests for information from government agencies, industry, environmental consultants, academics, and private citizens. The interrelated well, rock sample, and borehole geophysical log databases are accessed most frequently. For example, DGS scientists often pull samples out of approximately 43,000 rock samples in the repository, and it is not uncommon to re-examine samples collected by geologists in the 1950s to compare and correlate with recently acquired geophysical logs from wells.

In the 1980s, DGS developed a relational database management system (RDBMS) to facilitate the efficient mining of these repositories (see Summer 1985 issue of *First State Geology*). The key identifier for mining DGS repositories is a "DGSID" assigned to a boring,

well, or outcrop based on its location within a grid overlying the state. The locations of most of the points in the database were determined from topographic maps with 1-inch on the map representing 2,000 feet on the ground. Over the years, the latitude and longitude of wells and outcrops were hand-keyed into the database and locations were also plotted manually on well and outcrop maps. With the advent of readily available geographic information system (GIS) technology in the 1990s, DGS recognized the need to convert the maps from paper to digital format. At the same time, DGS recognized the opportunity to identify and remediate input errors (inherent to all databases) for the well and outcrop locations and to redesign the input procedure to minimize future errors.

The Map Conversion Project was initiated in 2000 (see Summer 2001 issue of *First State Geology*) to fulfill these needs and was completed in 2003. Rigorous quality control utilizing a systematic approach ensured that the points on the paper maps were digitized and correctly identified and located. Using an automated process, the hand-plotted locations were compared to the latitude and longitude that were typed into the database over the years. An algorithm flagged all pairs of points that were more than 60 meters (~200 ft) apart and the correct position for these points was determined by evaluating paper and digital records associated with the DGSID. This systematic method ensures that most points in the database are now within 200 ft (1/10 inch on a 1:24,000-scale map) of the location recorded when the data were collected. Many of the points have better positional accuracy both relative to the recorded and actual field locations; however, this was not systematically verified for all wells and outcrops. When a DGS project requires higher spatial resolution, true positional accuracy is further evaluated and locations are updated in the database. Staff and customers can now access GIS-based maps from within the DGS computer network that depict well and outcrop locations updated in real-time. Procedural guidelines and database rules were redesigned to further minimize input errors.

As the Map Conversion Project wound down, DGS geared up a concerted effort to populate the geophysical log and rock sample databases to ensure they are representative of the large amount of data in the repositories and to optimize their map-based access via GIS. Major milestones were reached in the last few months that now enable GIS depiction of all geophysical logs along with rock samples from onshore Delaware.

Geospatial Barn Raising at GIS Conference

By W. S. Schenck

Geospatial Barn Raising was the theme of the Delaware GIS 2004 conference held at the Dover Downs Hotel and Conference Center on April 20. The theme for this year's conference was an analogy to a barn—the structural center of the farm used to organize, store, and protect both the tools and yield of farming. The Delaware Spatial Data Framework (DSDF) is the essential structural center of Delaware's GIS community. It is used to organize the many geospatial data efforts of the government, private sector, and academia, and it stores the basic geospatial data needed by all GIS users. While the Delaware GIS community did not gather around rough-hewn plank tables to feast on home-made stews, breads, and pies, the end result—friends and neighbors gathering together to work and celebrate as a community—was realized.

The morning keynote speakers included State Budget Director Jennifer Davis and Hank Garie, the executive director of the federal government's "Geospatial One Stop." Bill Burgess, Washington liaison for the National States Geographic Information Council (NSGIC) spoke on NSGIC initiatives across the United States. Governor Ruth Ann Minner spoke at the closing plenary session and presented the 2004 GIS in Education Award on behalf of the state's GIS community.

The annual GIS in Education Award honors Delaware teachers who are instrumental in furthering the use of spatial data and geographic information systems in education. The award is open to all elementary, middle, and high school teachers in Delaware. Cindy Cunningham and Vicki Friend, both fourth-grade teachers at Richard A. Shields Elementary School, and Lori Roe, technology specialist with the Cape Henlopen School District, were presented the award. Their students looked at landscape changes that have occurred over time in the Roosevelt Inlet and Cape Henlopen areas of coastal Sussex County. Presenting the awards, Governor Minner said, "I have the pleasure, as I have in the last several GIS conferences, of recognizing the work of Delaware's teachers. Our teachers are using GIS software and data in their classrooms to help our children, who are our future, learn more about this wonderful state."

Framework discussion forums were held to enable the Delaware GIS community to take part in planning the future of the DSDF layers. Five layers (boundaries, elevation, hydrology, cadastral, and transportation) were selected for facilitated discussions centered on three themes: "Where are we now?" "Where do we go from here?" and "How do we get there?"

Award winners pictured left to right, Vicki Friend, Lori Roe, and Cindy Cunningham.

Twenty-two posters were presented at the conference, including posters prepared by Delaware Geological Survey staff members Lillian Wang, Andrew Klingbeil, and Matthew Martin. Lillian's presentation, "Application of GIS in Geologic Mapping - 1:100,000 Surficial Geologic Map of Delaware," depicted the current status of the DGS STATEMAP project to create a geologic map of the entire state at a scale of 1:100,000. STATEMAP is a cooperative effort between the U.S. Geological Survey (USGS) and state geological surveys to produce geologic maps. Andrew presented a poster entitled "Hydrologic Mapping of the Surficial Unconfined Aquifer in Eastern Sussex County, DE." The poster outlined the methods used to map thickness and estimate transmissivity of the unconfined aquifer in this area. Preliminary grids of aquifer thickness and estimated transmissivity were shown to illustrate how GIS is being utilized in the mapping effort. Matthew presented "Inland Bays Water-Table Mapping" which illustrated the various steps of data collection and analysis and how a water-table surface can be created using GIS. The poster highlighted the progress being made on the State Water-Table Mapping Project and informed viewers of the creation and management of grid surfaces and raster datasets.

Conference attendees chose winners from among nearly 100 entries in a K-12 GIS contest entitled "Building a Map - One Layer at a Time." Participation enabled students to creatively demonstrate their understanding of how map layers can be organized by features, such as streams and roads, or by type of data, such as lines and polygons. Congratulations to Mrs. Friend's fourth-grade class at Shields Elementary, Ms. Cunningham's fourth-grade class, also at Shields Elementary, and to Sarah Murphy of Milford Middle School for awards of first, second, and third place, respectively.

Two Important Units Formalized

By A. S. Andres

The Delaware Geological Survey released Report of Investigation No. 67, a new technical report entitled "The Cat Hill Formation and the Bethany Formation of Delaware." This report formally names two important water-bearing lithostratigraphic units in Sussex County. The report provides information that is useful to geologists, hydrologists, water-resource and land-use managers, engineers, and water well contractors for identifying and describing the Cat Hill Formation, which contains the

Manokin aquifer, and the Bethany Formation which contains the Pocomoke aquifer. Nearly all public water supplies in coastal Delaware from Indian River Inlet to Ocean City, Maryland are obtained from aquifers in these two formations as demand increases and shallower sources of water become less desirable for use. The report can help guide anticipated growth and economic development and help develop and protect ground-water resources.

Lithostratigraphy is a subdiscipline of geology concerned with the organization and systematic description of rocks and sediments based on their composition and relationships to other rocks and sediments. Most geologic maps and reports produced in Delaware describe lithostratigraphic units. Lithostratigraphic names can be formalized only after carefully documenting the results of scientific study and meeting a series of published rules. Other schemes used to organize and describe rocks and sediments may rely on fossil content (biostratigraphy) or sediment or rock ages (chronostratigraphy).

Report of Investigations No. 67 is available in pdf format from the DGS web site at http://www.udel.edu/dgs/ under "Publications." Printed copies of the publications may be requested by contacting the Survey at (302) 831-2833, via email at delgeosurvey@udel.edu, or by visiting the DGS office at the University of Delaware.

Publications

Recent DGS Publications

Report of Investigations

No. 66, Ground-Water Recharge Potential Mapping in Kent and Sussex Counties, Delaware, A. Scott Andres, 20 p.

No. 67, The Cat Hill Formation and Bethany Formation of Delaware, A. Scott Andres, 8 p.

Open File Reports

No. 45, Characterization of the Potomac Aquifer, an extremely heterogeneous fluvial system in the Atlantic Coastal Plain of Delaware, Thomas E. McKenna, Peter P. McLaughlin, Jr., and Richard N. Benson, 3 sheets plus explanatory text.

Staff Notes

Presentations

A. Scott Andres, "Water Resources of Southern Delaware, A Review," panelist on discussion, "Save It or Pave It? Achieving a balance between resource protection and land development in Kent and Sussex counties," Rehoboth Beach, June 8.

Richard N. Benson, "Geology of the Pencader Area, Delaware," Pencader Heritage Association, Newark, May 21.

Andrew Klingbeil and **A. Scott Andres**, "Hydrologic Mapping of the Surficial Unconfined Aquifer in Eastern Sussex County, DE," Delaware GIS 2004 Conference, Dover, April 20.

Matthew J. Martin and **A. Scott Andres**, "Inland Bays Water-Table Mapping," Delaware GIS 2004 Conference, Dover, April 20.

Thomas E. McKenna, "Rocks and Water," Newark Charter School, Newark, May 4, and at West Park Place Elementary School, Newark, May 6.

Kelvin W. Ramsey, "Hurricanes Then and Now: Disaster Can Happen Here," Hurricane Awareness and Preparedness Week, Newark, May 20.

William S. Schenck, "Delaware's State Boundaries," Delaware Geographic Data Committee, Dover, February 19, and Calvary Christian Academy, Dover, March 12; led the "Delaware Piedmont" field trip, Delaware Nature Society, March 20; co-chaired the Delaware GIS 2004 Conference and presented "Status of Delaware's Boundary Framework Layer," Dover, April 20; "Delaware Piedmont Geology," Delaware Native Plant Society annual meeting, Ashland Nature Center, May 22; "Delaware Piedmont Geology: Just what Rocks are Holding up Them-Thar Hills," Marian Coffin Gardens at Gibraltar, Wilmington, March 18, and at Winterthur Gardens, Winterthur, September, 2003. Also in 2003, "Delaware Geology" and "An Introduction to the Delaware DataMIL," Delaware Nature Society Teacher Education Class, July 22; led a field trip to Plank's Quarry and spoke about Delaware geology, Gunning Bedford Teacher in-service day, November 11; "Rocks and Minerals," MOT Charter School, Middletown, November 21.

John H. Talley and Stefanie J. Baxter, "Water Supply Development, Northern New Castle County—Meeting the Water Needs of 2020," Delaware River Master Advisory Committee Meeting, Newark, May 6.

Lillian T. Wang, "Application of GIS in Geologic Mapping-1:100,000 Surficial Geologic Map of Delaware," Delaware GIS 2004 Conference, Dover, April 20.

Service and Awards

Thomas E. McKenna was given a secondary appointment as an Associate Professor in the Department of Geology at the University of Delaware. He also participated with "Map N' Math," at Math Nite, West Park Place Elementary School, March 30.

Peter P. McLaughlin, Jr. began a one-year term as President of the North American Micropaleongology Section of the Society for Sedimentary Geology in April. He also was elected a director-at-large of the American Association of Stratigraphic Palynologists for a three-year term.

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First State Geology is published by the Delaware Geological Survey, a State agency established by an Act of the Delaware General Assembly in 1951 and organized as a unit of the University of Delaware.
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