



CENTER FOR THE BUILT ENVIRONMENT / ANNUAL LIVABLE BUILDINGS AWARD

DISCOVERY ELEMENTARY SCHOOL

ARLINGTON PUBLIC SCHOOLS — ARLINGTON, VIRGINIA



VMDO



“I think what is most important about this building is that *it allows teachers to think about how we learn and how students learn*. Curriculum is just something the state gives to us and you can teach that anywhere, but with this space, we can really get creative, and experiment, and shepherd meaningful experiences for students.”

ERIN RUSSO — PRINCIPAL
DISCOVERY ELEMENTARY SCHOOL

While built to address rapidly growing student enrollment in Arlington, Discovery Elementary School was designed to prove what can truly be achieved with a new public school facility. Every nook and cranny of the school is arranged to create a seamless integration between design, sustainability, and learning. It is the first school to achieve LEED Zero Energy certification in addition to achieving Gold under the LEED for Schools v2009 rating system.

The school shares the site with an existing middle school and has been master planned for future middle school expansion. Open, programmable space is preserved as much as possible by situating a full third of the building’s footprint on existing slopes. The school tiers into an existing hill to minimize the perception of its size while featuring exterior materials that are residential in nature and scale. Pre-K and Kindergarten students are grouped into three “kinderhouses” that mimic the size and spacing of adjacent homes.

Discovery Elementary inspires students and teachers to use the building creatively to facilitate everyday learning and lifelong exploration. To support engagement at every scale, the school features an extensive array of exterior playscapes and interior furniture including stools, bean bags, benches, height-adjustable tables and chairs, reading steps, and even a two-story slide — all of which encourage creative expression and student choice.

Inside classrooms, flexible details such as foldable partitions, retractable garage doors, and various furniture offerings support teacher collaboration and cross-pollination. Throughout the school, one-to-one technology enables research and collaboration to happen anytime, anywhere. Dry erase and magnetic creativity walls encourage student expression and ownership; Scrabble and Lego walls fuel linguistic and spatial exploration; and the “Hedge” (which encloses and defines the Kindergarten “Backyard”) provides nooks and crannies that buzz with activity before, during, and after school.

With a reconfigurable range of learning spaces, the positive correlation between learning, high performance architecture, and student engagement continues to find expression in all types of unanticipated ways — demonstrating that Discovery should continue to provide meaningful settings for educational practices that are always evolving.

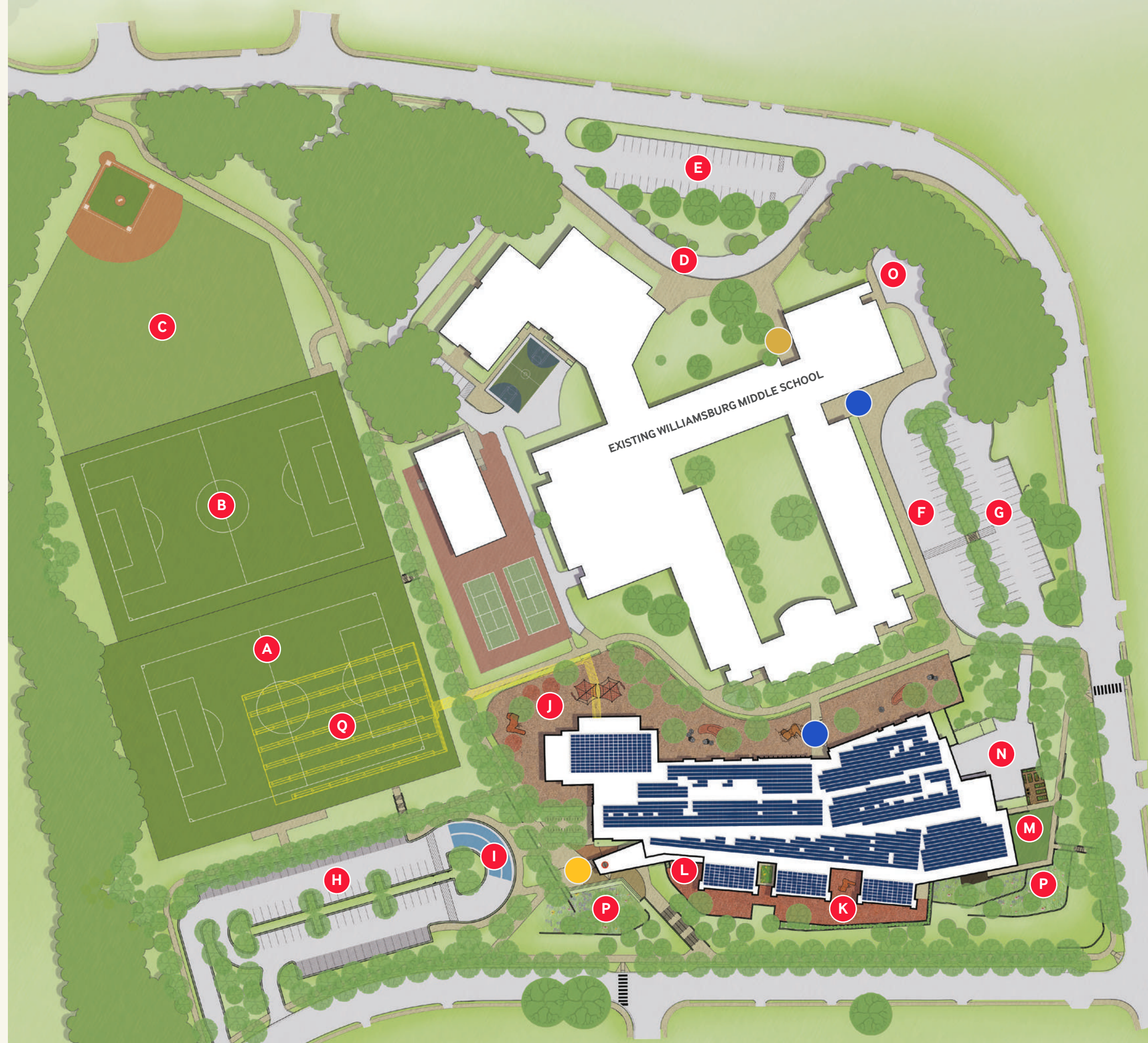


SITE PLAN

Discovery Elementary School

97,588 sq ft | 14.7 acres

- Building Primary Entry (Pedestrian + Vehicle Rider)**
- Building Secondary Entry (Bus Riders)**
- A** Artificial Turf Field One
- B** Artificial Turf Field Two
- C** Multi-Sport Field
- D** MS Vehicular Drop-Off
- E** MS Parking Area
- F** Joint MS/ES Bus Loop
- G** Joint MS/ES Parking Area
- H** ES Parking Area
- I** ES Vehicular Drop-Off
- J** ES Elementary Play Area
- K** ES Early Childhood Play Area
- L** ES Dedicated Pre-K Play Area
- M** ES Outdoor Dining + Play Area
- N** ES Service Court
- O** MS Service Court
- P** Bio-Retention Basins
- Q** Geothermal Wellfield



WHAT DOES OUR ATMOSPHERE DO?

Earth's five-layered atmosphere provides more than just the air we breathe. It also serves as a buffer that keeps us safe from meteorites and harmful radiation. The lowest layer is the troposphere and although it only extends 11 miles high, it provides most of our weather and contains four-fifths of the earth's air.

The atmosphere is 78% nitrogen, 21% oxygen, and a 1% mix of argon, carbon dioxide, helium, and neon.

KEEP THE AIR CLEAN

You breathe about 2 gallons of air every minute or 3,400 gallons of air each day! Taking the bus, carpooling, walking, or riding a bike to school can reduce air pollution from cars and help keep the air clean!

HOW DOES OUR SCHOOL GET CLEAN, FRESH AIR?

There are 58 sensors in our school that measure carbon dioxide, a gas released by breathing. When too much carbon dioxide builds up in any one room, the sensors call for outdoor air to be provided. This air is first filtered and de-humidified. A classroom of 20 people can exhale enough carbon dioxide to require fresh air after 30 minutes.

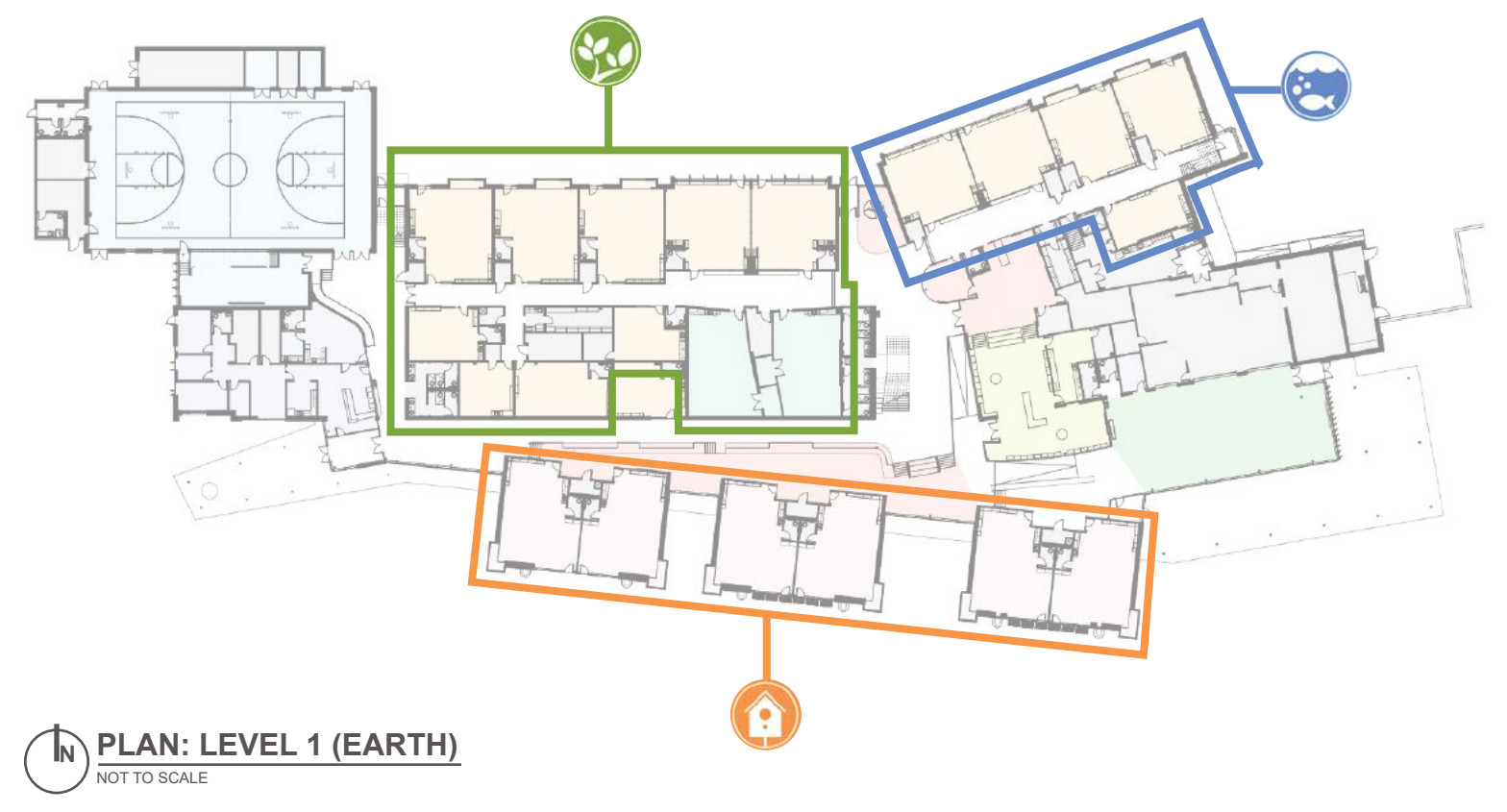
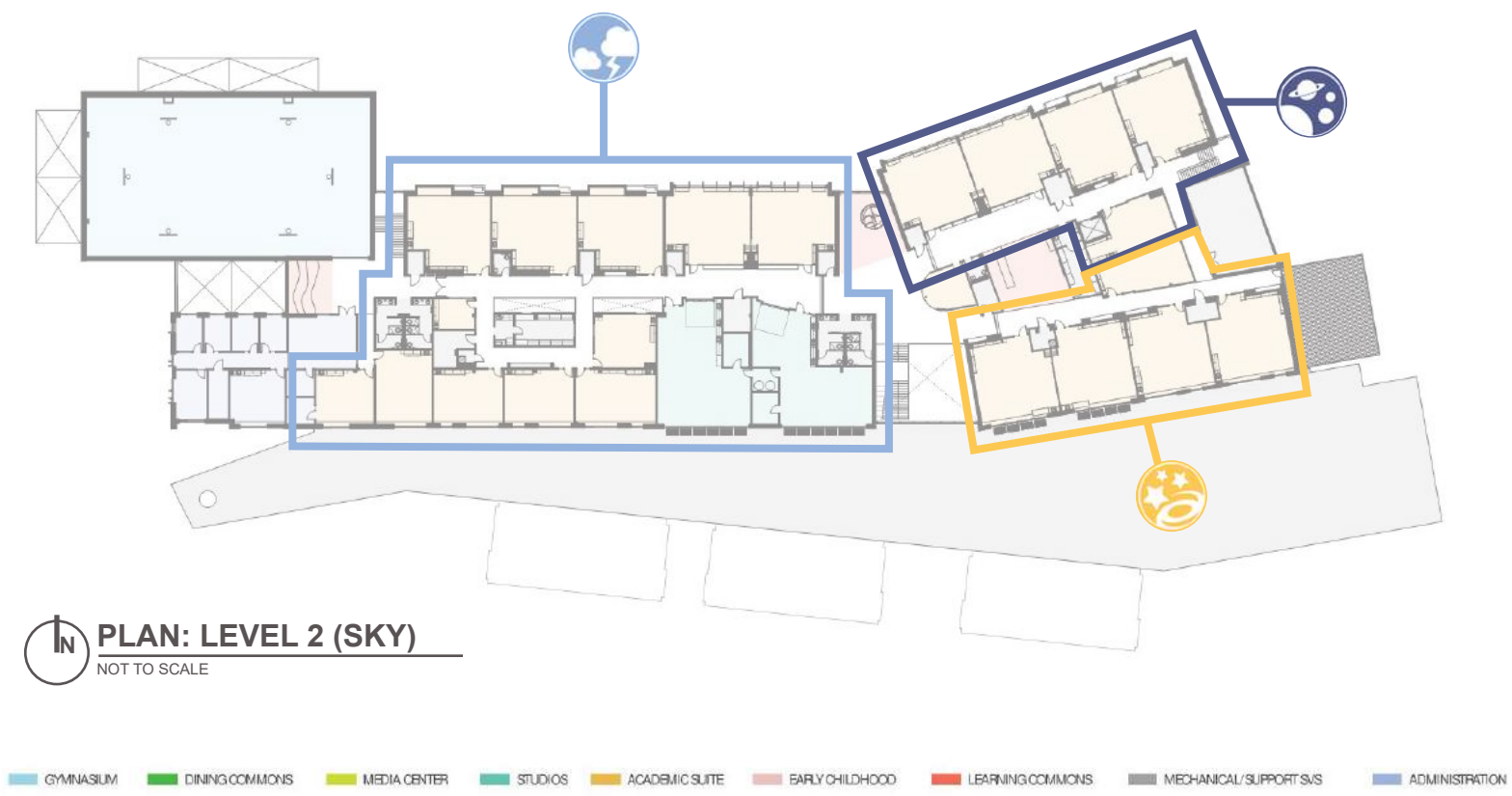
167 solar panels are needed to offset the total energy usage of our school's outdoor air system.

ATMOSPHERE AVIATORS (Air)

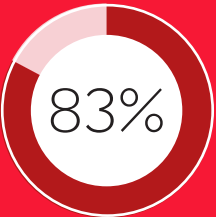
➔ Building as a Teaching Tool

The school's wayfinding goes beyond basic navigation to support a larger vision of spatial organization that reflects each grade's expanding curriculum and identity. As students progress through the school, their "world expands" – with the first floor themed around animals found in earth eco-systems and the second floor themed around the elements of the sky and heavens. Students start out as Backyard Adventurers in Kindergarten and finish Fifth Grade as Galaxy Voyagers.

This storyline is graphically communicated along an entry wall highlighting each Explorer grade level. On the first day of school, Explorers are able to "make their mark" in their expanding world by signing their name on the wall – and follow along as the mark moves down the wall over their six year journey at Discovery.



83% of survey respondents said the building raises their environmental awareness and encourages them to make sustainable choices



→ Energy

At the time of its completion, Discovery Elementary School was the largest zero-energy school in the US. The challenge was to integrate a 98,000 sq ft building into a residential neighborhood. By terracing the mass into a south facing hill, the project met local goals for scale, community goals for preservation of flat, open space for recreation, and global goals for ideal orientation for solar generation. Discovery offers a positive example of a solution to the global crisis of climate change—and along the way emboldens students with the expectation that they are creative participants in those solutions.

There were numerous challenges - foremost was the fact that the project was budgeted for LEED Silver only and no extra funds were made available for net zero. While K-12 schools are good candidates for net zero because of limited usage, Arlington schools operate year-round from 6am to 6pm with heavy weekend and evening use.

The neighbors rejected ground mounted PV arrays, and the local utility wouldn't allow an array larger than 500kW. An array of that size mandated an EUI of 23 or under. The design team also decided to stay off the sprawling roof of the neighboring middle school—as it wasn't a replicable solution, and that roof space would one day be needed to deal with the middle school's energy footprint.

Passive design strategies included high thermal mass through ICF construction, a terraced building section that brought light deep into the building while maximizing roof top space for PV, and a relentless focus on air-sealing—which produced a building that tested at 0.12 cfm/sq ft: 80% better than code.

Light is celebrated throughout, from colorful sunshades, to a solar lab connected to a custom designed dashboard, to a solar calendar in the front entry plaza.

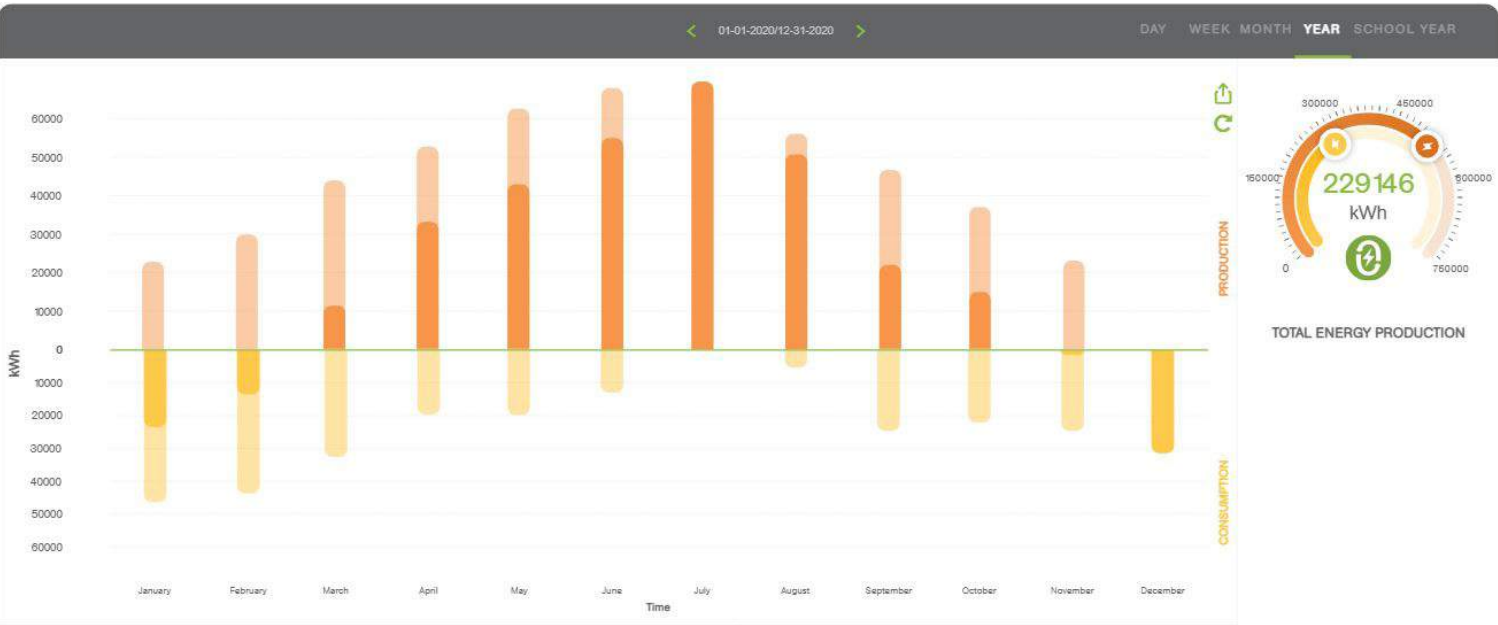
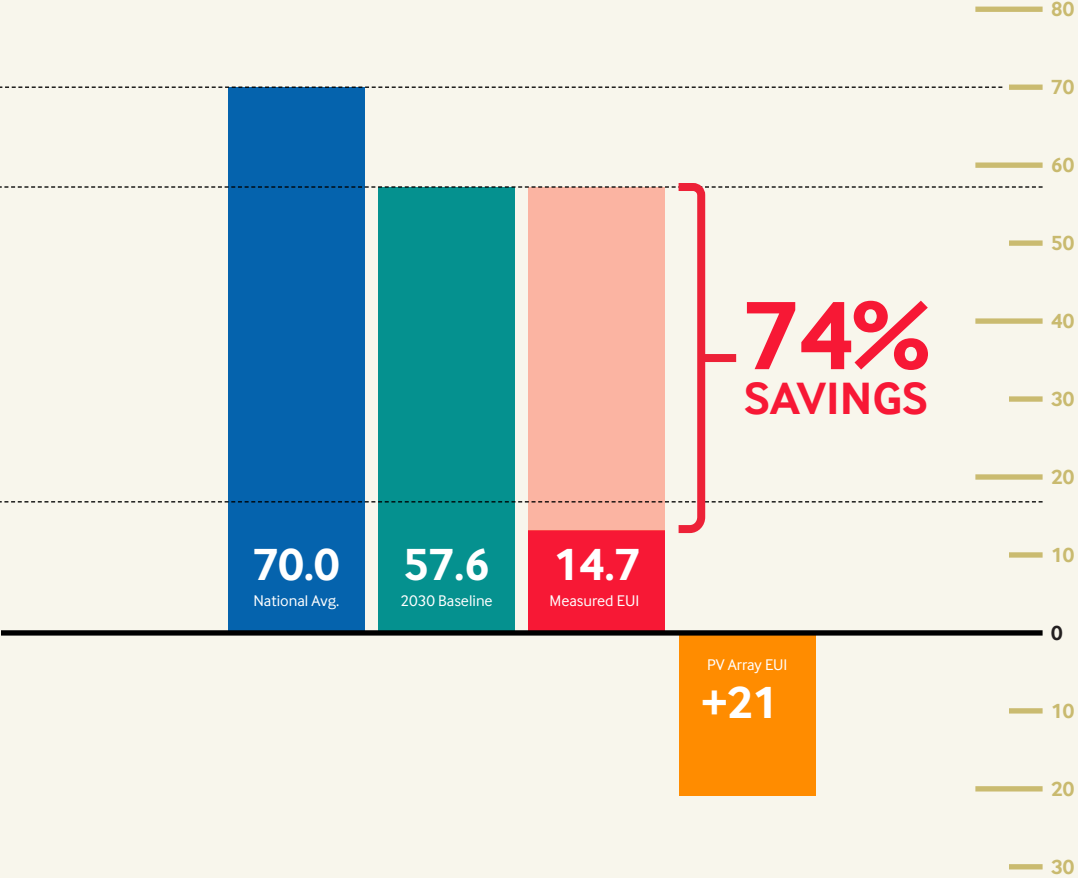
→ Benchmarking

US National K-12 Average (Site)
70 EUI

2030 Baseline
57.6 EUI

2030 Target (70%)
17 EUI

- National Avg.
- 2030 Baseline
- Measured EUI
- PV Array EUI



(Above) Discovery's building management system reports real-time consumption and production to an online energy dashboard, used by educators daily to engage students in the lessons of the building. The screen shot above shows just how net-positive the project was during 2020. (Right) Students also have the opportunity for hands-on experimentation in the solar lab.



Discovery's annual cost of ownership of \$0.11/sf, **a 92% reduction** compared to ACPS's elementary school average of \$1.32/sf.



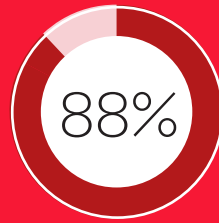
CONSERVATION

- SOLAR ORIENTATION**
The sun rises low in the east, hangs high overhead to the south, and sets in the west. Our school is oriented with the sun to the south, allowing it to provide natural light and heat during the day. North windows receive light without the extra heat from direct rays of sunlight, and south windows are shaded with exterior sun screens.
- BUILDING ENVELOPE**
The envelope is the "skin" of the building, separating inside from outside. Our school's walls, windows, and doors are designed to be extremely air tight. This is especially important in very cold and very hot times of the year, when the outside temperature is significantly different than the inside temperature.
- THERMAL MASS**
Thermal mass is the ability of a material to absorb and store heat. The solid parts of our exterior walls are built with foam blocks filled with concrete. The walls absorb heat from the sun during the day and slowly release it back out at night - keeping it cooler in summer and the building at a stable temperature with less heating and cooling.
- SENSORS**
Sensors are used throughout our school to measure things such as temperature, air quality, and whether or not a room is being used. This creates a smart building that provides the exact amount of air and light only when it's needed. Rooms can "power down" when not being used.
- LIGHTING**
Windows, solar tubes, and skylights throughout our school provide the source of light, saving energy in addition to these natural light sources, all of our electric lights are energy efficient lights. Existing fixtures are replaced and are expected to last up to 50 years each.
- ALL-ELECTRIC KITCHEN**
Our kitchen prep area food line is healthier and energy efficient. Rather than using natural gas, a hood fan, all of the kitchen equipment is powered with electricity. Power is often generated with the combustion of fossil fuels, so equipment that uses natural gas and electricity produces extra heat and requires more energy to cool down.
- ROOF SHAPE**
The school's curving roof acts as a large overhang for much of the south-facing glass on the first floor. It also allows for lots of natural light with great views outside. The roof also provides room for all of the required solar panels, while also providing shaded outdoor space and an outdoor area for the solar collectors.

PRODUCTION

- GEOTHERMAL ENERGY**
Our school's heating and cooling systems process heat in the ground during warm months and pull heat from the earth when it's cold, using water circulating through pipes that run deep underground. The ground holds heat without ever losing renewable energy source to heat and cool the building.
- SOLAR PANELS**
The 1,718 solar panels on our roof absorb sunlight to make electricity. They make up a photovoltaic system that works best in full sunlight, but can also produce energy on cloudy days. The system can generate enough electricity to offset the amount of energy used by our school every year.
- BUILDING MASSING**
Knowing where the sun is at any time of a building is key. In some ways, our school is shaped like a power plant. The roofline of the building also operates from south to north, preventing the high north from casting shadows on the low south. This maximizes the solar exposure to direct sunlight for the solar panels.
- SOLAR HOT WATER**
Solar hot water systems absorb solar energy from the sun's rays and convert it into thermal energy. Two hot water collectors on our roof absorb solar energy that is used by our school's showers. The panels are at two different angles, which generate different amounts of hot water depending on the time of year.

88% of survey respondents said
the school is a community asset



→ Resources

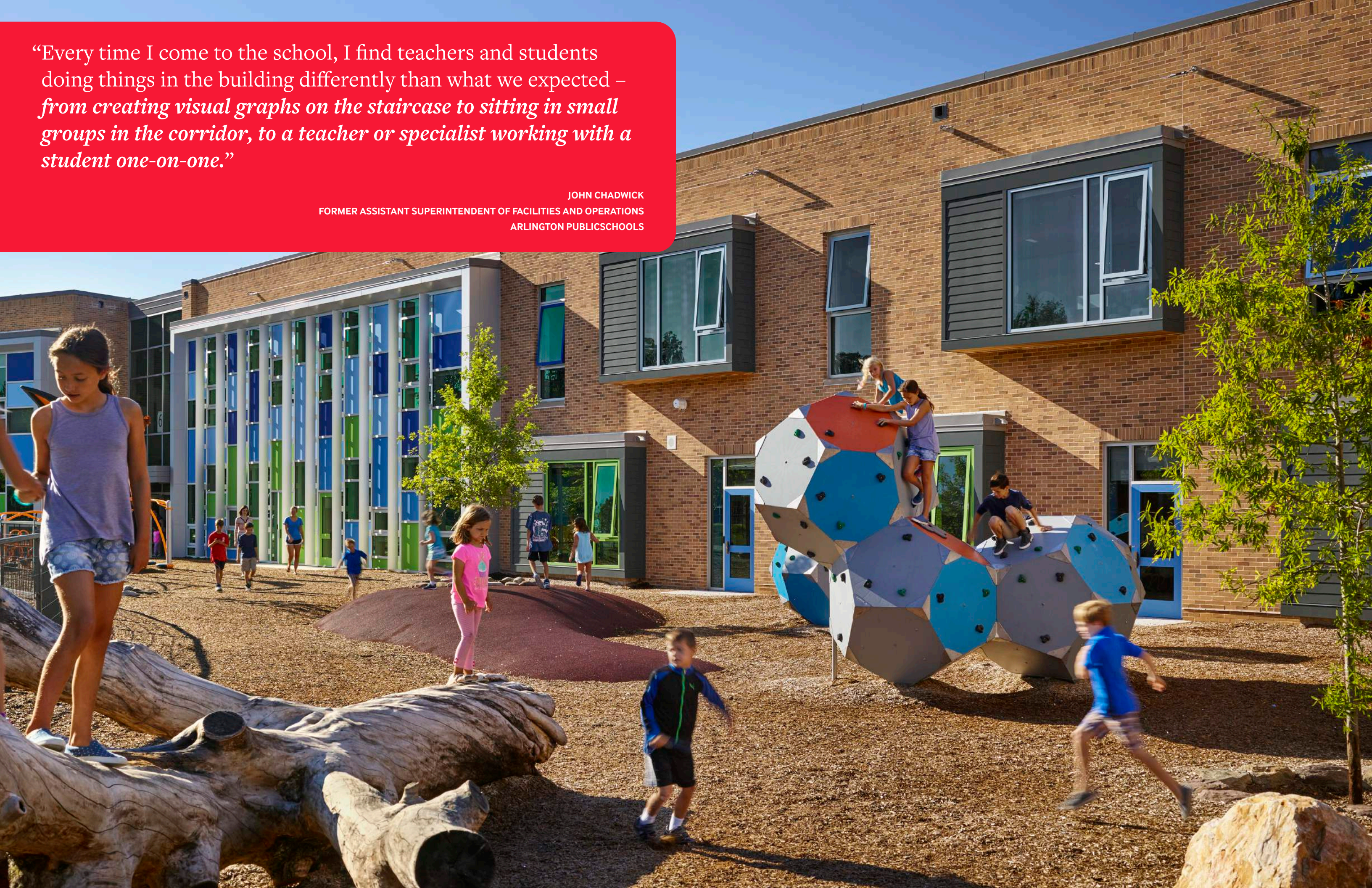
All materials, systems, equipment and operating decisions underwent a photovoltaic (PV) offset analysis—how much PV would be needed to offset the annual energy costs of that selection? For example, triple-pane insulated glass was considered at an additional cost of \$119,000. It would've provided some annual energy savings—but that same amount could be produced onsite with \$9,000 of PV panels. This type of analysis was applied to all selection decisions and was instrumental to meeting a zero-energy goal with minimal materials. Notably, over-conservative amounts of polystyrene roof insulation were reduced.

In support of the design objective of humane and joyful spaces, interior CMU was replaced with high-impact, high recycled content gypsum wall board with corner guards. The exterior envelope was a load-bearing insulated concrete wall system (one of the first in the region)—allowing for a significant reduction in the high levels of embodied energy contained in structural steel, as well as a reduction in the overall number of materials used in the wall assembly. Once concrete was on the job, it was used for all the site retaining walls and left exposed. Where large retaining walls faced neighboring homes, they were faced with locally sourced stone.



“Every time I come to the school, I find teachers and students doing things in the building differently than what we expected – *from creating visual graphs on the staircase to sitting in small groups in the corridor, to a teacher or specialist working with a student one-on-one.*”

JOHN CHADWICK
FORMER ASSISTANT SUPERINTENDENT OF FACILITIES AND OPERATIONS
ARLINGTON PUBLICSCHOOLS



→ **Wellness**

A high 38 percent glazing percentage allows for abundant natural light and views deep into the building, supplemented by 62 Solatubes. LEED-for-Schools acoustic criteria are met throughout and every single ground floor classroom has direct access to the exterior.

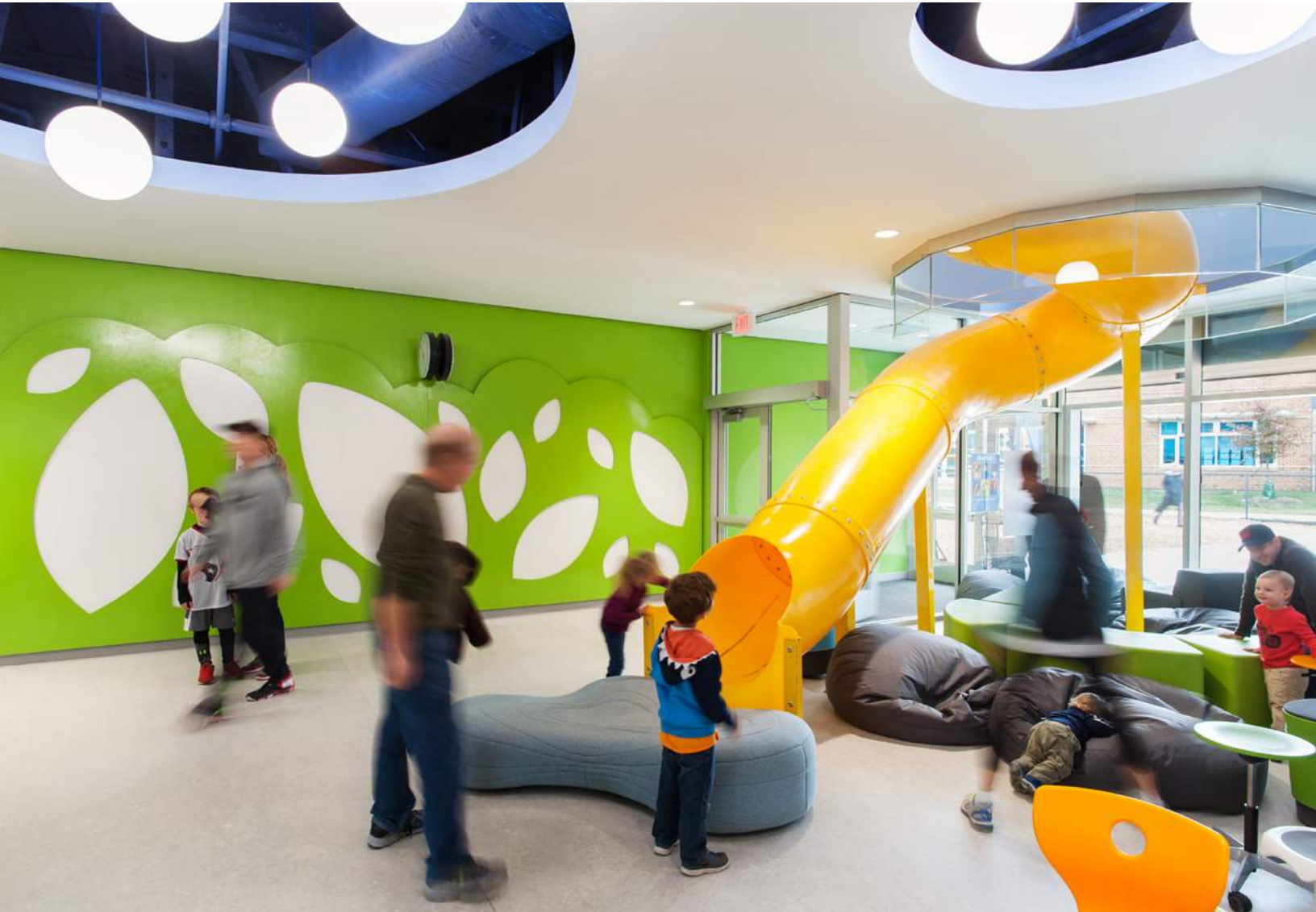
A lab-quality sensor constantly monitors CO₂ levels in every regularly occupied space and all break-out instructional spaces: a total of 61 monitoring points. When any space exceeds 700 ppm, an increased rate of fresh air is supplied. As research continues to evolve on the effect of indoor air quality and cognition, the set points on the system can be changed to accurately reflect best practices.

90% of survey respondents
said that the building makes
them feel happy



Three distinct outdoor spaces were deliberately placed directly outside of the dining commons, allowing for a single point of visual supervision: a covered space that accommodates outdoor dining and provides space for rainy day exercise; a school garden with direct adjacency to the kitchen; and an open turf play lawn separate from playgrounds with equipment.

These spaces recognize that lunch is also a movement and activity time separate from recess, and that short periods of movement help increase overall consumption of healthy menu options. Combined with school-grown food items, a culture of health is promoted through design.



“There’s a difference in the amount of light and openness here. Students feel like they’re at camp... *Before they’re even in their classrooms for the day, just in the hallways, they’re happy to be here.*”

Discovery Educator





The efficient design of Discovery's kitchen saves **15 kBtu/sf/year** + eliminates fried foods from the menu.

→ Community

The site is ideal for a school: average walking distance is $\frac{3}{4}$ of a mile and the longest is approximately 1.7 miles. On walk/bike-to-school days, participation reaches nearly 90 percent. Seven buses serve the school, all running on biodiesel fuel.

Discovery's sustainable environment sets an expectation of stewardship: the student Eco-Action team tracks transportation mode statistics daily and publishes them on the school dashboard. Lunch trash is weighed each day and tracked, along with donations of unopened food to the local food bank.

The school's solar calendar in the entry plaza was poured the summer after occupancy, allowing the students to work directly with the architects to accurately mark the position of the sunspot for each hour of the school day on the equinoxes and

82% of survey respondents said
the building enhances their
connections with students

82%

the summer solstice. In this sense, Discovery's learners literally helped plan one the school's best educational features.

As the smallest county in the United States in area, the civic process in Arlington is rooted in a very high level of community engagement. Three major groups worked directly with the design team:

Instruction: division leaders and in-school educators

Building: neighbors, parents, and civic association representatives

Public Facilities: representatives from planning, transportation, environmental, and parks & recreation commissions



“This is the greatest green school I’ve ever seen. It is fully integrated with the educational program and serves as a pedagogical tool.”

RACHEL (GUTTER) HODGDON
FORMER DIRECTOR — CENTER FOR GREEN SCHOOLS;
CEO — INTERNATIONAL WELL BUILDING INSTITUTE



➔ Project Team + Cost

01 Project Team:

- Prime Architect: **VMDO Architects**
- Mechanical, Lighting, ZE Design: **CMTA Consulting Engineers**
- Power, Plumbing and Fire Protection Engineering: **2rw Consultants, Inc.**
- Structural Engineering: **Fox & Associates**
- Civil Engineering: **Bowman Consulting Group**
- Landscape Architecture: **Oculus**
- Foodservice Design: **EIS, Inc.**
- Cost Estimating: **Downey & Scott**
- Construction Manager: **Heery**

02 Project Cost:

Owners Budget	\$33,600,000
Final Hard Cost at Close-out	\$32,710,130*
Cost/sf (with PV array)	\$333/sf

* Project came in \$2 million under budget, so PV array and 2 turf fields were included in project costs

“Discovery isn’t just a school building. Every aspect of the environment is built for and used for learning. *We aspire to its example, and strive to implement innovative, research-based, future-proof practices that mirror the potential of this space.*”

KEITH REEVES — EDUCATIONAL TECHNOLOGY ADMINISTRATOR
DISCOVERY ELEMENTARY SCHOOL

