## Scoring Methods- Environmental Indicators

**The overall Environment score was calculated as** the average of the scores for each of the following indicators: Pervious Surfaces, Protected Habitat, Protected Waters, Living Shorelines, and Forests. Each of these indicators is vital to the resilience of the Charles County Environment against changing conditions, particularly those related to climate change. Of these indicators, all but Protected Waters and Water Quality were scored at the watershed level, as well as the County level. Sufficient watershed level data were not available for Protected Waters and Water Quality.

## Indicator: Pervious Surface

**Background:** Pervious Surfaces soak up rainwater during storm events, reducing the risk and magnitude of floods. Impervious surfaces, on the other hand, cannot absorb water, and therefore contribute to flooding during storm and high tide events. Areas with impervious surface covering less than 5% of land area are considered to be ecologically protected, and it is estimated that every 1% increase in impervious surface increases flood magnitude by 5.6%.

**Data:** Total acreage data were obtained from the MDE Nonpoint Source Model, taken from https://www.charlescountymd.gov/home/showpublisheddocument/3674/637958177846030000. Current (2023) impervious surface area coverage at the watershed level was provided by Karen Wiggin, Planner, Charles County Government.

**Methods & Thresholds:** At the watershed level, Pervious Surface was scored so that if impervious surface made up 5% or less of a watershed, that watershed scored 100%. If impervious surface exceeded 5% of a watershed, the score was reduced by 5.6% (from 100%) for each 1% increase in impervious surface coverage over 5%. The county-level score was calculated as the area-weighted sum of watershed-level scores.

**Indicator: Protected Habitat**

**Background:** The USGS categorizes protected lands based on how much "protection for biodiversity conservation" and natural habitat they are given (Protected Areas Database of the United States). Lands are assigned to the following four categories, called "GAP Status Codes"

"Status 1 – Managed for biodiversity with natural disturbance events allowed (for example, Wilderness, Research Natural Areas, some National Parks, some State or NGO Nature Preserves)"

"Status 2 – Managed for biodiversity with management that may interfere with natural processes (for example, suppress wildfire or flood)"

"Status 3 – Permanent protection, but the land is subject to multiple uses (forestry, farming, intensive recreation, etc."

"Status 4 – No known institutional mandates to prevent conversion of natural habitat types"

In this assessment, Protected Habitat is defined as areas that fall within GAP Status categories 1 through 3 because these categories provide some level of permanent protection focused specifically on biodiversity and habitat. Maintaining biodiversity and habitat ensures that climate change mitigation benefits conferred by habitats are also maintained. For example, protected forests sequester carbon and maintain microclimates in addition to providing homes for a diversity of species.

In it's Kunming-Montreal Global Biodiversity Framework, The Convention on Biodiversity set a goal of preserving 30% of the planet's lands and waters worldwide. In February of 2021, President Joseph Biden committed the United States to achieving this goal, known colloquially as "30x30" (https://www.eli.org/vibrant-environment-blog/30x30-what-ambitious-and-visionary-goal-could-mean-our-ocean). Hundreds of countries worldwide have also committed to this goal.

This indicator measures how close Charles County is to permanently protecting and managing 30% of its total land area specifically for biodiversity and habitat.

**Data:** Data on GAP status of Charles County lands was downloaded from the Protected Areas Database (USGS), NOAA, and MD DNR.

**Methods & Thresholds:** The proportion of lands that fall within GAP Status 1, 2, and 3 was compared to the 30x30 target of protecting 30% of lands. The score was calculated based on how close Charles County is to meeting this goal; if 30% of lands were protected, the county would score 100%. The same method was used for calculating watershed level scores.

**Indicator: Protected Waters**

**Background:** The USGS categorizes protected waters based on how much "protection for biodiversity conservation" and natural habitat they are given (Protected Areas Database of the United States). Waters are assigned to the following four categories, called "GAP Status Codes".

"Status 1 – Managed for biodiversity with natural disturbance events allowed (for example, Wilderness, Research Natural Areas, some National Parks, some State or NGO Nature Preserves)"

"Status 2 – Managed for biodiversity with management that may interfere with natural processes (for example, suppress wildfire or flood)"

"Status 3 – Permanent protection, but the land is subject to multiple uses (forestry, farming, intensive recreation, etc."

"Status 4 – No known institutional mandates to prevent conversion of natural habitat types"

In this assessment, Protected Waters are defined as waters that fall within GAP Status categories 1 through 3 because these categories provide some level of permanent protection focused specifically on biodiversity and habitat. Maintaining biodiversity and habitat ensures that climate change mitigation benefits conferred by habitats are also maintained. For example, oyster reefs provide slow wave action, helping reduce flood and erosion risk. Most protected waters in Charles County are National Marine Sanctuaries or Oyster Sanctuaries.

In its Kunming-Montreal Global Biodiversity Framework, The Convention on Biodiversity set a goal of preserving 30% of the planet's lands and waters worldwide. In February of 2021, President Joseph Biden committed the United States to achieving this goal, known colloquially as "30x30" (https://www.eli.org/vibrant-environment-blog/30x30-what-ambitious-and-visionary-goal-could-mean-our-ocean). Hundreds of countries worldwide have also committed to this goal.

This indicator measures how close Charles County is to permanently protecting and managing 30% of its total waters specifically for biodiversity and habitat.

**Data:** Data on GAP status of Charles County waters was downloaded from the Protected Areas Database, NOAA, and MD DNR.

**Methods & Thresholds:**

The proportion of waters that fall within GAP Status 1, 2, and 3 was compared to the 30x30 target of protecting 30% of lands. The score was calculated based on how close Charles County is to meeting this goal; if 30% of lands were protected, the county would score 100%.

## Indicator: Living shorelines

**Background:** Shoreline erosion was identified as a key threat to the human safety, property and natural resources in Charles County. While many practices have been used to stabilize shorelines, NOAA recommends the establishment of living shorelines because they are less impacted by coastal change than many other shoreline stabilization options (https://www.fisheries.noaa.gov/insight/understanding-living-shorelines#what-are-the-main-benefits-of-living-shorelines). Living shorelines also provide habitat for wildlife and recreational opportunities for people while improving water quality. Living shorelines are a practical and attractive long-term approach to shoreline protection.

**Data:** Living shorelines data comes from the Virginia Institute of Marine Science's Maryland Shoreline Inventory (https://www.vims.edu/ccrm/research/inventory/maryland/).

**Methods & Thresholds:** This indicator was scored by calculating the percent of the coastline that was classified as either forested or marsh for subwatersheds (HUC-8 level) at both the County level and the Watershed level. Cobb island was scored as a separate "watershed".

Erosion rates from the Maryland Department of Natural Resources Living Shorelines Project () could potentially also be used to identify priority areas for placing living shorelines.

## Indicator: Forests

**Background:** Forests provide ecosystem functions that protect against climate change. In addition to storing carbon and improving air quality, Forests provide natural flood management and reduce erosion. Forest cover helps maintain microclimates by cooling shaded areas and reflecting heat. The Sustainable Forestry Council recommends that 40% of land be maintained as forest cover; this is a broadly accepted target used in development planning around the world.

**Data:** Forest cover data came from the National Land Cover Database.

**Methods & Thresholds:** This indicator was scored against the 40% threshold. At the county level score, each watershed was assigned a value of 100% if meets or exceeds the 40% goal or 0% if it does not. The area-weighted sum of these values is the county level score. Watershed level scores were calculated as the percent of the way to the 40% goal each watershed is. So, if a watershed is 40% or more forested is scores 100%, if it is 20% forested it scores a 50%, and so on.

## Indicator: Water Quality

**Background:** Stream water quality measures can indicate how well able a stream is adapting to, or will be able to withstand, extreme weather and climate events. Multiple variables of water chemistry are important, and a suite of parameters was used to calculate water quality. Specific conductivity indicates (among other things) the amount of road salt that has run off into the stream, degrading water quality. pH indicates whether water is acidic enough, or too acidic, to support important biodiverse species. Water temperature can impede fish reproduction, and is an indicator how much increasing temperatures impact streams. Dissolved oxygen is crucial for allowing aquatic species to respirate.

**Data:** Data are from various stream sampling sites in the County were downloaded from the EPA Water Quality Data Portal, covering the years 2021–2023. Data for nutrients like nitrogen and phosphorus were also available, but nutrient values are not necessarily linked to climate-related changes. Additionally, thresholds that are specific to tidal and non-tidal waters were not readily available, so nutrient indicators were not used.

**Methods & Thresholds:**

**Specific conductance** values were rescaled from 0–100 based on ecoregion standards from the Sampling and data analysis protocols for Mid-Atlantic non-tidal stream indicators, which determined ecologically relevant conductivity thresholds by comparing conductivity levels to various benthic macroinvertebrate metrics. Each sample value was scaled, and scaled values were averaged together for the specific conductance score. The resulting score is 63%.

**pH** values were scored pass/fail based on whether they fell outside a range of normal values set by the Environmental Protection Agency. Values that fall below the range of normal values scored a 0; these samples are noteworthy because they indicate exceptionally low pH and acidic water. Values that fall above the range of normal values also scored a 0, because high pH extremes were also deemed noteworthy for water quality and consistency over time. All scored values were averaged together, resulting in a score of 91%.

**Water temperature** values were scored pass/fail based on the temperature tolerance of the yellow perch in the Chesapeake Bay, which is a maximum of 32℃ according to the Maryland Department of Natural Resources. This threshold was chosen because of the value of yellow perch as a recreational fishery in Maryland. Temperature values that are above 32C scored a 0, while all values below 32C scored a 100. These scores were then averaged together, resulting in a score of 74%.

**Dissolved oxygen** was only scored in the warm months May through September, when it is more likely that water DO levels will hit critical low points. The threshold of 5 mg/L was pulled from the Sampling and data analysis protocols for Mid-Atlantic non-tidal stream indicators. All DO values that fell below this threshold scored a 0, while everything above the threshold scored a 100. Sample scores were then averaged together, resulting in a score of 96%.

Once these four water quality indicators were scored, they were averaged together for an overall water quality score. The score is 81%. These specific water quality indicators are responsive to changing climate and coastal resilience stressors, providing a comprehensive look at the impact of climate change on water quality in Charles County, Maryland.

## Scoring Methods- Human Well-being Indicators

**The overall Human Well-being score was calculated as** the average of the scores for each of the following indicators: Heat Tolerance, Park Equity, Tree Equity, Air Quality, Preserved Open Space, and Groundwater Management. Each of these indicators how well protected human communities are against extreme events, particularly those related to climate change. Of these indicators, Heat Tolerance, Park Equity, and Tree Equity were scored at the watershed level, as well as the County level. Sufficient watershed level data were not available for Air Quality, Preserved Open Space, and Groundwater Management.

## Indicator: Heat Tolerance

**Background:** A key feature of climate change is a shift towards hotter weather. According to a report by the World Meteorological Organization, the next four years will see an average of 1.5˚C increase in global temperatures compared to the pre-industial era. The effects of increased temperatures will not be felt uniformly, and it is important to understand which areas will be more vulnerable to extreme heat so that measures can be taken to alleviate the burden on those communities.

**Data:** Data were transcribed from an embedded map in this NBC news article into a spreadsheet labeled "Extreme Heat Vulnerability 20240724.csv". The data is based on the Heat Model by First Street. More information on their methodology can be found here. The population numbers were determined to be from the US Census Bureau's 2019 Data for census tracts.

**Methods & Thresholds:** The percent of people who are NOT vulnerable to extreme heat was calculated for each census tract in Charles County. These percentages were weighted by the proportion of the total watershed population and summed for county level and watershed level scores.

## Indicator: Park Equity

**Background:** Access to quality green space improves quality of life. Neighborhoods with parks nearby allows residents access to outdoor space, encouraging exercise and recreation. Parks can also have a cooling effect in urbanized areas, because trees provide shade and reflect the sun's heat rather than absorbing it. Not all residential areas have equal access to quality parks. Lower-income and underrepresented neighborhoods tend to have lower park access, which increases the divide in quality of life.

**Data:** Data were from the Maryland Department of Natural Resources Park Equity Mapper.

**Methods & Thresholds:** The DNR Park Equity Mapper calculates scores of equitable and sufficient park access based on demographic data, such as race or age, in combination with park data including amenities, walkability, and public transit access ate the Census Block Group level. Park equity scores for each Census Block Group were rescaled from the Park Equity Mapper scores to a scale of 0 to 100%. Census block group scores were weighted by proportion of population and summed for watershed and county level scores.

| Park Equity | Letter Grade | Score |
|---|---|---|
| 0.23–0.24 | A | 80–100 |
| 0.25–0.26 | B | 60–79 |
| 0.27–0.29 | C | 40–59 |
| 0.30–0.32 | D | 20–39 |
| 0.33–0.36 | F | 0–19 |

## Indicator: Tree Equity

**Background:** Trees are critical urban infrastructure that are essential to public health and well-being. Tree Equity Score was created to help address damaging environmental inequities by prioritizing human-centered investment in areas with the greatest need (TreeEquityScore.org).

The geographic focus of urban infrastructure should be considered when assessing tree equity. Highly developed areas are more likely to receive pedestrian traffic and use by non-residents. A well-shaded downtown benefits anyone who visits, while neighborhood trees primarily benefit neighborhood residents.

**Data:** Tree equity scores at the census block level were obtained from American Forests' Tree Equity Score website.

**Methods & Thresholds:** The percentage of census blocks in Charles County that are scored by American Forests as having 100% tree equity score was calculated to attain the county score.

## Indicator: Air Quality

**Background:** Ozone is a major pollutant that is harmful to human health in high concentrations. Other aspects of air quality that impact human health are particulate matter concentration and acid deposition, but only Ozone data were available for Charles County. This indicator determines how healthy Charles County's air is based on EPA standards for Ozone concentration in air.

**Data:** Daily ozone measurements for the last year were downloaded from the US EPA Outdoor Air Quality Data webpage (Download Daily Data | US EPA). The EPA collates data from multiple sources into single, annual data spreadsheets. The most recent full year of available data were used.

### Methods & Thresholds

Each daily ozone measurement was compared to the EPA's Air Quality Index values for ozone and rescaled from the EPA's scoring range of 0-301 to a 0-100 scale as shown in the table below.

| Levels of Concern | Values of EPA Index | EPA Description of Air Quality | Charles County Score Range | Letter Grade |
|---|---|---|---|---|
| Good | 0 to 50 | Air quality is satisfactory, and air pollution poses little or no risk. | 100-81% | A |
| Moderate | 51 to 100 | Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution. | 61-80% | B |
| Unhealthy for Sensitive Groups | 101 to 150 | Members of sensitive groups may experience health effects. The general public is less likely to be affected. | 41-60% | C |
| Unhealthy | 151 to 200 | Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects. | 21-40% | D |
| Very Unhealthy | 201 to 300 | Health alert: The risk of health effects is increased for everyone. | 0-20% | F |

**Indicator: Preserved Open Space**

**Background:** In 2006, Charles County established a goal of preserving 50% of the county's land area, or approximately 147,000 acres, in open space 2022 Land Preservation, Parks, and Recreation Plan (LPPRP). Public, County, Municipal, State, and Federal lands can be considered "open space" if preserved properly.

**Data:** Data on the amount of Charles County Land preserved as open space came from the 2022 Land Preservation, Parks, and Recreation Plan (LPPRP).

**Methods & Thresholds:** This indicator was scored by calculating the percent of the way the county is to preserving 50% of land as open space.

**Indicator: Groundwater Management**

**Background: Methods & Thresholds:**

As climate change continues, ensuring the availability of water for human use- from drinking water to watering crops-is a growing concern. Charles County's water is drawn from underground aquifers, which naturally replenish very slowly over time, as rainwaters percolate through the ground and into the aquifer. When temperatures rise, less water reaches the aquifers. This means that as groundwater is used, it is not readily replaced. Water conservation is a key concern for the Charles County Department of Planning and Growth.

**Data:** Data on aquifer drawdown was provided by the Charles County Department of Planning and Growth.

**Methods & Thresholds:** Charles County has several aquifers, so if one aquifer becomes overused and water withdrawal must stop, another can be used. This indicator was scored based on whether 1) drawing down water stopped each time an aquifer became overdrawn and 2) whether stopping drawdown resulted in aquifer recovery. This has occurred twice in Charles County, and both times switching to another water source led to recovery of the overdrawn aquifer.

## Scoring Methods- Flooding

**The overall Flooding score was calculated as** the average of the scores for each of the following indicators: Road Flood Mitigation, Flood Mapping, Flood Insurance, Critical Facilities, Property Mitigation, and Business Preparedness. Each of these indicators how well protected human communities are against extreme flooding events, particularly those related to climate change.

## Indicator: Road Flood Mitigation

**Background:** Roads should remain passable during flood events in order for daily life to continue. It is most critical that roads that provide access to emergency services and escape routes remain passable, but any flooded or impassable road causes disruptions and potential danger.

**Data:** In the County Nuisance Flood Plan (NFP), fifty-seven roads are identified as being flood prone. Flood heights, and whether mitigation measures have occurred, are provided for each of these roads in the NFP.

**Methods and Thresholds:** First, each of 57 flood-prone roads was scored based on the risk posed, inferred from flood height, as follows: roads with reported water level of less than 1 foot of received a score of 80%, roads with water levels of 1-2 feet scored 40%, and roads with flood heights of 3 feet or higher scored 0%. After each road was scored according to risk level (as described above), scores were adjusted so that those roads that had been mitigated had 20% added to their score. The overall score was calculated as the average of individual road scores.

## Indicator: Flood Mapping

**Background:** Climate change is contributing to an increase in flooding impacts which are expected to worsen in the future. Comprehensive, publicly available, and easy-to-use data, maps, and visualizations for all types of flooding are essential to effectively plan for and adapt to flooding events now and into the future. There are mapping products available in Maryland, including but not limited to both regulatory and non-regulatory: FEMA flood maps, the Coast Smart Climate Ready Action Boundary, the Maryland State Highway Administration Climate Change Vulnerability Viewer, and local maps developed to visualize flood risk. These map products provide communities with a greater understanding of where flooding may occur; however, there is a need to continue to expand and enhance flood risk visualizations that prepare coastal communities for current and future impacts. As these visualizations are developed, technical assistance on how to apply, utilize, and interpret them at both a state and local level will be needed.

Current and future flood maps are an important part of the state's climate adaptation portfolio. State legislation passed in 2015 requires science-based sea level rise projections that include maps indicating the areas of the state that may be most affected by storm surges, flooding, and extreme weather events. It is also required that these projections shall be made publicly available online.

Progress has been made towards these mandated requirements; however, more work is needed. As identified in the 2015 legislation, the University of Maryland Center for Environmental Science (UMCES) in collaboration with the Scientific Technical Workgroup and Adaptation and Resiliency Workgroup of the Maryland Commission on Climate Change will map flooding risk in Maryland and make all results and products publicly available and accessible.

**Data:** The availability of flood tools for Charles County was assessed based on web searches and then confirmed by county officials.

**Threshold and Scoring:** Thresholds for score ranges, shown in the table below, were determined by a state-level stakeholder committee of flood experts and stakeholders, including members of the Maryland Department of Planning, Chesapeake and Coastal Services, and the Maryland Department of the Environment.

| Score Range (%) | Threshold Requirements |
|---|---|
| 80–100 | 1) Mapping products that show sea level rise, storm surge, nuisance flooding, and other flood risks through an integrated platform<br>2) Comprehensive technical assistance must be offered to all jurisdictions to support interpretation of these products |
| 60–80 | 1) Mapping products that show stormwater overflow risk<br>2) Revised relative sea level rise projections |
| 40–60 | 1) FEMA floodplain (100-year and 500-year)<br>2) Flood risk conveyed beyond the floodplain<br>3) SLR projections through 2150<br>4) Current and projected tidal nuisance flooding<br>5) Storm surge maps |

## Indicator: Flood Insurance

**Background:** This indicator evaluates how much of estimated future flood damage would be covered by current insurance policies. Flood insurance is only required in FEMA-identified flood risk areas, but floods in the near future are predicted to impact properties beyond these areas.

Flood insurance is available for properties not in the FEMA floodplain, but because it is not required, these areas may be un- or under-insured. This indicator considers how much of the property that is expected to be impacted in a 100-year flood is covered by existing flood insurance policies.

**Data:** Data were collected from two sources. The estimated value of properties that would experience insurable damage in a 100-year flood was found in FEMA Flood Risk Reports for each county. The Maryland Department of Emergency Management provided county-level information on flood insurance coverage.

**Threshold and Scoring:** Many insurance policies, including flood insurance policies, have an 80% rule. This requires property owners to purchase insurance coverage equivalent to 80% of the home's value in order to have the full amount of damage covered in case of an insurance claim. Therefore, the threshold for this indicator was set at 80%. The county was scored based on how close the summed value of insurance policies in the County are to reaching 80% of property values.

## Indicator: Critical Facilities

**Background:** Critical facilities, as defined by the Federal Emergency Management Agency (FEMA), are structures and institutions for which "even a slight chance of flooding is too great a threat." The State of Maryland identifies critical facilities as those that "must continue to operate before, during, and after an emergency and/or hazard event and/or are vital to health and safety." Maryland designates fire and police stations, hospitals and medical facilities, emergency operations centers, and schools as critical facilities.

Areas with especially high risk of flooding are designated by FEMA as Special Flood Hazard Areas (SFHA).

**Data:** Data on the number of critical facilities in Special Flood Hazard Areas were obtained from the Maryland Hazard Mitigation Plan.

**Threshold and Scoring:** Because FEMA indicates that "a critical facility should not be located in a floodplain if at all possible," the threshold for scoring of each critical facility was based on it NOT being in an SFHA. Each designated critical facility was scored individually, with a score of 100% being assigned for facilities not in an SFHA and a score of 0% assigned to those within SFHAs. The overall score was the average of individual facility scores.

## Indicator: Property Mitigation

**Background:** Repetitive loss properties are properties that have had two or more National Flood Insurance Program claims over $1,000 within 10 years. These properties may be adapted to better withstand threats of climate change by, for example, elevating them. This indicator assesses the proportion of repetitive loss properties with such adaptations implemented.

**Data:** Data detailing the repetitive loss properties and their status (whether mitigated or not) were provided by Charles County.

**Threshold and Scoring:** Because repetitive loss properties are likely to continue experiencing repeated flood damage as coastal change leads to increasing frequent and severe flooding, the threshold for this indicator is that all repetitive loss properties should be mitigated in some way. Each repetitive loss property was scored, with properties with some form of mitigation having occurred scoring 50% and unmitigated properties receiving a score of 0%. The overall score was calculated by averaging the property scores.

## Indicator: Business Preparedness

**Background:** Business disruption is a financially expensive result of coastal change events. Storms and floods, increasing with climate change, threaten short- and long-term business closures that may impact whole economies. The Congressional Budget Office calls a loss of 5% of annual income “substantial.”24 This indicator considers whether the expected business disruption cost from a climate change event exceeds 5%.

**Data:** Data on estimated loss due to business disruption in case of a 100-year flood were available in FEMA Flood Risk Reports for each county. Data on total county income were available from county-level Demographic and Socio-Economic Outlook Documents provided by the Maryland State Data Center.

**Threshold and Scoring:** Because the Congressional Budget Office calls a loss of 5% of annual income “substantial,” a 5% loss was set as a failing or 0% score for this indicator. Because stakeholders indicated that any loss caused by business disruption could be extremely damaging, a score of 50% was set for loss estimates of 0.01% of annual income or higher. Loss estimates between 0.01% and 5% were scaled for scores of 50% and 0% respectively. A loss estimates less than 0.01% would score 100%.