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MOUNTAIN MARYLAND

NextEra Energy Transmission MidAtlantic, Inc. and NextEra Energy Transmission Virginia, Inc.

ROUTING STUDY

MidAtlantic Resiliency Link (MARL)

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This document prepared by Engage Mountain Maryland summarizes the 144-page routing study for the MidAtlantic Resiliency Link Project (MARL), which evaluates potential routes for a new transmission line.

This routing study was conducted to identify optimal routes for the MARL project, a 107.5-mile, 500 kV transmission line across four states, Pennsylvania, West Virginia, Maryland, and Virginia, to minimize environmental and social impacts while ensuring reliable construction and operation.

Prepared by ERM on behalf of NextEra Energy Transmission MidAtlantic and Virginia, the study's goal is to select a route that minimizes impacts, maximizes use of existing infrastructure, and is cost-effective, while evaluating natural, built, cultural, and social environments and engineering feasibility. The purpose of the MARL line is to address reliability issues in PJM's 13-state region caused by excessive load growth due to data centers in Northern Virginia and energy facility retirements.

The MARL Project also includes a new 500/138 kV Woodside Substation in Frederick County, VA, and it will connect existing substations and construct new transmission infrastructure.

Project Scope and Key Components

The project involves constructing a new 500 kV transmission line and a substation, with 107.5 miles of transmission lines traversing four states and six feasible alternative routes.

The right-of-way (ROW) width averages 200 feet, with some areas requiring wider easements up to 426 feet. The project includes access roads, work pads, tower foundations, and the installation of lattice steel structures ranging in height from 85 to 190 feet, with an average span of 1,258 feet. Construction involves survey, ROW acquisition, foundation work, structure erection, and land restoration. Post-construction maintenance includes inspections and vegetation management. The project is designed to meet state and federal environmental standards, including stormwater and erosion controls.

Routing Methodology and Process

The routing process aims to develop feasible, environmentally conscious routes by assessing constraints, opportunities, and stakeholder input.

- The process begins with defining a broad study area based on PJM reliability needs.
- Geospatial data and GIS analysis identify existing infrastructure, environmental, and cultural constraints.
- Route alternatives are developed to avoid or minimize impacts, favoring paralleling existing linear features.
- Stakeholder engagement and field reconnaissance refine route options.
- The process evaluates routes based on impact, constructibility, cost, and permitting risks.
- The goal is to identify at least three feasible routes and select the best one as the Proposed Route.

Study Area Definition and Constraints

The study area encompasses the endpoints in Pennsylvania and Virginia, including diverse opportunities for paralleling existing infrastructure while considering environmental and land use constraints.

- The area includes roads, utility ROWs, residential areas, parks, wetlands, forests, and cultural sites.

- Data collection involved high-resolution aerial imagery and LiDAR, flown between December 2023 and February 2024.
- Constraints include natural resources, protected lands, water bodies, and cultural resources.
- Opportunities include existing utility corridors, roads, and planned developments.
- The geospatial database supports informed decision-making for route development.

Environmental and Cultural Resource Considerations

Environmental and cultural factors heavily influence route selection, aiming to avoid sensitive areas and minimize impacts.

- The study inventories wetlands, water bodies, floodplains, forests, and protected lands.
- Cultural resources include archaeological and historic sites, with efforts to avoid or mitigate impacts.
- Special considerations include natural heritage sites, scenic views, and habitats for threatened species.
- Data acquisition and GIS analysis support impact minimization and route optimization.
- The routing process prioritizes paralleling existing infrastructure to reduce habitat fragmentation and visual impacts.

Construction, Operation, and Maintenance

The project's construction involves detailed steps to ensure safety, environmental compliance, and efficiency, with ongoing maintenance for reliability.

- Construction steps include survey, ROW clearing, access road building, foundation installation, structure erection, and land restoration.
- Typical structures are lattice steel with four legs, with heights from 85 to 190 feet.
- Equipment used includes cranes, helicopters, earth movers, and stringing pullers.
- Foundations may be drilled piers or micropiles, designed based on geotechnical surveys.
- Construction materials are delivered within the ROW, with stormwater and erosion controls in place.

- Maintenance includes inspections, vegetation management, and land restoration to ensure reliable operation.

Overview of Transmission Line Routing Process

The document details a comprehensive, multi-phase routing process for the MARL Project, emphasizing data collection, stakeholder engagement, route analysis, and criteria development to identify the optimal transmission route with minimal environmental and community impacts.

Development of Preliminary Route Segments Using GIS

The Routing Team used GIS software and a constraint/opportunity database to develop initial route segments, avoiding natural, cultural, and social constraints, and considering constructibility and parallel routing opportunities.

- Data was collected via desktop sources, field reconnaissance, stakeholder/public engagement.
- Routes were validated and refined based on resource impact assessments.
- The process aimed to identify routes that minimize impacts and maximize existing infrastructure use.

Stakeholder Engagement and Public Feedback Methods

The team conducted extensive stakeholder and public outreach, including a project website, open houses, targeted mailings, virtual and in-person meetings.

- Public feedback was gathered through surveys, online maps, and comment pinning.
- Engagement aimed to gather local knowledge, identify sensitive resources, and refine route options.
- Feedback influenced route refinement and helped develop final alternatives.

Route Alternative Analysis and Final Route Selection

Data from reconnaissance and outreach was used to refine draft routes, evaluate alternatives, and compare advantages/disadvantages.

- Final routes considered environmental, land use, constructibility, and

public input.
- Routes deemed too impactful or infeasible were eliminated.
- Six full end-to-end route alternatives were identified, with a Proposed Route selected based on comprehensive analysis.

Route Development Criteria and Evaluation Methodology

Criteria were based on best practices, focusing on minimizing impacts on residences, land use, natural resources, and infrastructure.

- No explicit numerical weights were assigned; a hybrid qualitative-quantitative approach was used.
- Criteria included route length, paralleling existing lines, parcel crossings, environmental and cultural resources, and engineering considerations.
- The methodology aimed to balance technical feasibility with environmental and social impacts, ensuring transparent decision-making.

Conceptual Route Corridor Development

Broad corridors were developed within the Study Area, focusing on paralleling existing transmission lines, avoiding large constraints, and considering natural, built, and regulatory factors.

- The Study Area was divided into four quadrants: Northwest, Southwest, Central, and Eastern.
- Corridors prioritized existing linear features, minimized impacts on developed areas, and considered terrain and land use.
- Quadrant-specific strategies aimed to optimize route options and reduce environmental and community impacts.

Identification of Preliminary Draft Route Options

Within each quadrant, preliminary route segments were assessed and refined through data analysis, field verification, and stakeholder input.

- The process aimed to reduce segments to those most suitable for a new transmission line.
- About 310 miles of route segments were publicly shared as preliminary draft options.
- Field reconnaissance verified data and identified site-specific constraints

not visible in aerial imagery.

Stakeholder and Public Engagement Activities

Engagement efforts included online surveys, open houses, and mailed notifications to landowners and officials.

- The first survey phase (Feb-Apr 2025) received 540 responses, focusing on local concerns.
- The second survey phase (May-Jun 2025) received 719 responses, focusing on route options.
- Eight in-person open houses and a virtual session in October 2025 facilitated direct public input.
- Feedback helped refine routes, identify constraints, and support decision-making.

Summary

The MARL Project routing process integrated GIS analysis, stakeholder input, environmental and land use assessments, and flexible evaluation criteria to develop and select a route that balances technical, environmental, and community considerations.

Public Engagement and Community Input Summary

The project involved extensive public and stakeholder engagement across multiple formats to refine route options.

- In-person open houses held on May 8, 12, 13, 14, and October 14, 2025, in West Virginia, Pennsylvania, Virginia, and Maryland.
- Over 1,259 comments received via online survey by June 6, 2025, providing critical qualitative insights.
- Community feedback helped refine route segments, eliminate routes with unacceptable impacts, and incorporate landowner and stakeholder concerns.
- Virtual open house focused on crossing Maryland Wildlands System.
- Community hotline and email provided ongoing input.
- Engagement with local, state, and federal agencies offered technical, regulatory, and data support.
- Public input influenced transition from conceptual corridors to refined

segments, leading to six final route alternatives.

Route Refinement and Segment Elimination Process

The Routing Team evaluated 84 route segments to develop feasible alternatives, dismissing some based on constraints.

- 35 segments dismissed due to engineering, environmental, or land use concerns.
- 49 segments carried forward, with 41 refined (shortened, rerouted, or adjusted).
- Segments were combined into longer route groupings for final alternatives.
- Key reevaluations included segments like 13d and 20b, over 8 and 14 miles respectively.
- Final routes composed of refined segments resulted in six end-to-end alternatives.
- The process balanced stakeholder feedback, technical feasibility, and environmental considerations.

Final Route Alternatives and Selection

Six end-to-end route alternatives (A through F) were developed, each with unique alignments and impacts.

- Alternative Route A: 107.5 miles, 2,669 acres ROW, parallels existing lines 52.5%, crosses all four states.
- Alternative Route B: 107.3 miles, 2,671 acres ROW, parallels lines 55.6%, slightly shorter than A.
- Alternative Route C: 113.6 miles, 2,835 acres ROW, parallels 56.8%, avoids some protected areas.
- Alternative Route D: 115.2 miles, 2,839 acres ROW, minimizes impacts on certain wildlands.
- Alternative Route E: 106.3 miles, 2,651 acres ROW, shortest route, highest paralleling percentage.
- Alternative Route F: 119.1 miles, 2,964 acres ROW, longest, highest land disturbance.
- Routes A, B, and E are most compact, with the shortest length and smallest footprint.
- Routes F, C, and D have broader footprints and longer alignments, with

higher impacts.

Route Impact on Land Use and Social Resources

The evaluation focused on minimizing impacts on parcels, landowners, and residential structures.

- Alternative Routes A and E: lowest impacts, fewer landowners (388 and 367), fewer dwellings within 250/500 ft.
- Alternative Route B: higher impact, 403 landowners, 192 dwellings within 500 ft.
- Alternative Route C: 405 landowners, 161 dwellings within 250 ft.
- Alternative Route D: moderate impact, 308 outbuildings, 199 non-residential buildings within 500 ft.
- Route F: highest impact, 535 parcels, 42 dwellings within 250 ft, 63 outbuildings.
- Aiming to avoid impacts on residential dwellings and landowners, especially in sensitive areas.

Impact on Protected Areas and Natural Resources

Routes were designed to minimize crossing protected lands, including forests, wildlands, and conservation easements.

- All routes cross some protected areas like Youghiogheny River Lake and Maryland Wildlands.
- Routes C and F avoid crossing Coopers Rock State Forest.
- Routes A, B, D, and E avoid crossing Maryland Wildlands and White Horse Mountain WMA.
- Several routes cross conservation easements, with efforts to minimize impacts.
- Total protected land crossings range from 5 to 10, with miles from 13.3 to 17.2.
- Impact minimization aimed to reduce ecological disturbance and streamline permitting.

Route Paralleling Existing Infrastructure

Paralleling existing transmission lines reduces visual and environmental impacts.

- Routes A, B, and C: highest paralleling, over 52% of their length.
- Route E: 47.7% paralleling, 50.8 miles.
- Route F: lowest paralleling, 36.3%, with 43.2 miles.
- Greenfield sections vary, with Routes A and B having around 47-48 miles.
- Paralleling maximized where feasible to reduce land disturbance and visual impacts.

Overall Route Performance and Selection Criteria

Routes were assessed on length, footprint, land use, environmental, and social impacts.

- Routes A, B, and E: superior performance, minimized impacts, compact alignments.
- Route E: shortest, smallest footprint, highest paralleling.
- Routes C and D: moderate impacts, longer alignments, broader footprints.
- Route F: longest, largest impact, lowest paralleling.
- Final selection balanced technical feasibility, impact reduction, and stakeholder input, with Routes A, B, and E leading as preferred options.

Protected Lands and Impact Overview

The analysis evaluates the impacts of alternative transmission routes on protected lands, cultural resources, natural environment, and infrastructure, highlighting route-specific impacts and performance.

Protected Lands Crossed by Routes

The routes cross various protected areas, with impacts varying by route.

- Alternative Route D has the lowest impact, crossing 5 protected lands over 13.3 miles and impacting 328.6 acres.
- Routes A, B, E, and F cross 6 to 8 protected areas, with impacts ranging from approximately 366 to 435 acres.
- Route C crosses 10 protected lands, with the highest impact of 17.2 miles and 435.5 acres.
- Impacted protected lands include state forests, wildlands, WMAs, and conservation easements.
- Impact calculations avoid double counting, especially for White Horse Mountain WMA.

Cultural Resources Evaluation

Routes were assessed for proximity to cemeteries, archaeological sites, historic districts, and heritage areas.

- Route A had the best performance, with 4 cemeteries, 6 archaeological resources, and crossing 6 historic districts.
- All routes crossed the Hanging Rock Battlefield, with impacts of 38 acres.
- Route C crossed the most architecture resources (13) and had the highest impact on Friendship Hill NHL.
- Route D performed well, crossing the fewest NRHP/NHL resources (6) but impacted the most historic districts (6).
- Routes A, D, and E provided the lowest impacts on cultural resources, with minimal differences among them.

Impacts on Water Resources

Routes were evaluated for crossings of streams, wetlands, floodplains, and waterbodies.

- Route A had the lowest impact, crossing 42.6 acres of wetlands and 81 perennial streams, with 13,513 feet of trout streams.
- Route B also performed well, with 77 perennial streams and 33 trout stream crossings.
- Route C had the highest impact on wetlands (59.6 acres) and 76 streams.
- Route D had the most stream crossings (99) and the longest linear feet (30,557.4).
- Route F had the worst performance, with the highest impacts on streams, wetlands, and floodplains.

Sensitive Species and Habitats

Routes were assessed for impacts on habitats of threatened, endangered, and sensitive species.

- Route A had the second-lowest impact on potentially suitable species habitats, with 2,650.8 acres.
- Route B also performed well, with 2,651.8 acres impacted.
- Route E had the lowest impact on these habitats, with 2,634.2 acres.

- Route C had moderate impacts, with 2,809.5 acres.
- Routes D and F had the highest impacts, with 2,823.0 and 2,941.5 acres respectively.
- All routes impacted habitats for bats, monarch butterflies, and other species, with Routes A, B, and E being the most environmentally favorable.

Engineering and Infrastructure Challenges

Routes were evaluated based on existing crossings, structure complexity, terrain, and proximity to infrastructure.

- Route A had the fewest structures (452), with 41 structures having 20–30° turn angles and 50 over 30°.
- Route A also had the lowest number of 500 kV crossings (7) and spans over 1,600 feet (33).
- Route B had similar structure counts but more sharp turn structures (47 with 20–30°, 59 over 30°).
- Route C faced more engineering challenges with 13 crossings and 478 structures.
- Route F had the highest number of structures (519) and crossings, with 12 500 kV crossings.
- Terrain steepness varied, with Routes A and B crossing 1.6 miles of very steep slopes.
- Infrastructure crossings included roads, pipelines, and oil/gas wells, with Route A having the fewest oil/gas wells (4).

Summary

The evaluation highlights Route D as the least impactful on protected lands, while Routes A, B, and E offer the best balance of environmental performance and engineering feasibility, with Route F showing the highest environmental impacts.

Evaluation of Alternative Routes for Transmission Line

A comprehensive assessment was conducted to compare six alternative routes based on engineering, environmental, community, and cost criteria, leading to the selection of the most balanced route.

Performance of Alternative Route C

Alternative Route C showed inferior engineering performance due to high complexity.

- Had the worst engineering score among routes.
- Highest counts for transmission line crossings (11), pipelines, and oil/gas wells within ROW and 500 ft.
- Traverses heavily developed natural gas areas in Pennsylvania.
- Average structures: 478, with many sharp angles.
- Only 31 spans longer than 1,600 feet.
- Positioned as less favorable due to engineering challenges.

Performance of Alternative Route D

Alternative Route D demonstrated moderate engineering performance.

- Highest number of 138 kV crossings (23).
- Second-lowest 500 kV crossings (7).
- Structures: 492, second-highest.
- 109 turn-angled structures (>20°).
- Avoids steep terrain by routing north of Bear Creek, Maryland.
- Crosses near two wind farms with 7 turbines within 0.5 miles, adding engineering challenges.

Performance of Alternative Route E

Alternative Route E performed best for engineering and infrastructure.

- Lowest total structures: 446.
- Second-lowest turn-angle structures: 94.
- Lowest 500 kV crossings: 7.
- Offers a more cost-effective design.
- Balanced routing with fewer complex features.

Performance of Alternative Route F

Alternative Route F had the poorest engineering performance.

- Longest length with 519 structures.
- Highest turn-angle structures: 129.
- Highest 500 kV crossings: 11.

- Traverses heavily developed natural gas regions in Pennsylvania.
- Crosses near two wind farms.
- Elevated oil and gas infrastructure presence.
- More complex and costly.

Summary of Superior and Inferior Routes

- Routes A and E excelled across most criteria, with Route A balancing length, infrastructure, and community impacts.
- Routes C and F performed poorly, especially in engineering and environmental impacts.
- Route D was moderate, with some advantages in protected areas.
- Cost estimates: A ($1.167B), B ($1.176B), C ($1.205B), D ($1.241B), E ($1.160B), F ($1.256B).

Route Evaluation and Selection Process

- Multi-criteria evaluation considered length, footprint, existing infrastructure, community, protected areas, cultural, natural resources, engineering, and costs.
- Route A scored "Superior" in most categories, with only moderate in protected lands.
- Route A was chosen as the Proposed Route for its balanced performance and minimal impacts.

Comparison of Proposed Route with Alternatives

- Overlap with other routes ranged from 20.2% (F) to 87.1% (E).
- Route B overlaps 73.4%, deviates in residential areas, and has more structures and greenfield development.
- Route C overlaps 64.4%, longer by 6.1 miles, with higher impacts on community and protected lands.
- Route D overlaps 67.5%, with larger greenfield footprint and more miles in Maryland.
- Route E overlaps 87.1%, shortest, with fewer impacts but more greenfield in West Virginia.
- Route F overlaps only 20.2%, with the highest impacts and additional miles of greenfield development.

Final Proposed Route and Environmental Mitigation

- Route A spans 107.5 miles, with a ROW of 2,669 acres, mostly paralleling existing lines (52.5%).
- Begins in Greene County, PA, and ends in Frederick County, VA.
- Traverses multiple counties with detailed routing avoiding residential and protected areas.
- Incorporates ancillary facilities like access roads, structure pads, and wire work areas.
- Preserves 20 riparian habitat zones covering 26.3 acres to minimize environmental impacts.
- Impact analysis shows reduced disturbance with riparian zone preservation, especially on water and natural resources.
- The route design emphasizes balancing infrastructure needs with environmental and community considerations.

Land Cover and Habitat Impact Overview

The analysis compares land cover and habitat impacts between proposed routes with and without riparian habitat exclusion zones, highlighting environmental considerations and land use changes.

- No riparian route excludes riparian habitat zones; with riparian route includes them.
- Differences in land cover values are bolded or italicized.
- Acreage calculations exclude areas within the ROW corridor.
- Deciduous forest total decreases from 1,836.0 to 1,823.8 acres with riparian zones.
- Total forest lands reduce from 2,031.4 to 2,011.0 acres when riparian zones are considered.
- Developed land totals decrease slightly from 100.4 to 96.3 acres with riparian zones.
- Land cover types such as cultivated crops, grassland, and wetlands show minor variations between routes.

Water Resources and Stream Impacts

The water resources analysis details stream and waterbody crossings, highlighting changes in stream counts, lengths, and wetland areas between routes.

- Perennial streams decrease from 81 to 61; intermittent streams remain at

37.
- Stream corridor length reduces from 27,326.6 to 21,432.4 feet with riparian zones.
- Waterbody count remains at 14; area decreases from 4.2 to 3.2 acres.
- Navigable waters reduce from 3 to 2; corridor length decreases from 13,513.2 to 8,150.1 feet.
- Trout streams and designated use streams show reductions in counts and lengths.
- Modeled wetlands decrease from 42.6 to 36.6 acres.
- Wetlands of special concern and freshwater wetlands show slight reductions.
- Flood zone areas decrease from 101.9 to 91.8 acres.
- Total flood zone area reduces by approximately 10 acres when riparian zones are included.

Sensitive Species and Habitat Considerations

The assessment identifies critical habitats, species occurrences, and ecological resources affected by the routes, noting differences with riparian zones.

- USFWS critical habitat remains at 0.0 acres; proposed habitat is 0.9 acres for both routes.
- State-listed species occurrence slightly decreases from 235.1 to 233.5 acres.
- Potentially suitable habitat for species like MBTA and foraging bats reduces marginally.
- Bat occupied summer habitat decreases from 104.3 to 102.4 acres.
- Modeled bat roosting habitat reduces from 2,033.9 to 2,013.5 acres.
- Irreplaceable natural areas decrease from 88.7 to 82.4 acres.
- Forest interior species and natural heritage areas show minor reductions.
- Significant habitats such as BioNet tiers and ecological cores are slightly reduced.
- No critical habitats or ecological cores are entirely avoided; impacts are minimized where possible.

Engineering and Infrastructure Features

The engineering analysis compares existing infrastructure crossings, structure counts, topography, and geologic features for routes with and without riparian zones.

- Both routes have 11 unknown kV transmission line crossings; no change.
- Structure count remains at 452 for both routes.
- Crossings include various road types, railroads, and pipelines, with minor differences in geologic karst features.
- Geologic karst features are approximately 12 miles and 302.9 acres for both routes.
- Topography shows similar miles in steep and very steep slopes.
- Infrastructure crossings such as roads, railroads, and pipelines are consistent across routes.
- Within the corridor, 4 oil and gas wells are present; no change with riparian zones.
- Wind turbines are absent within 500 feet or 0.5 miles of the route.
- No airports are within 20,000 feet.
- Infrastructure crossing counts and geologic features are similar, with minor variations in mileage and acreage.

Routing Study and Final Route Selection

The routing study aimed to minimize environmental and engineering impacts while maximizing existing infrastructure use.

- Six alternative routes were analyzed; Alternative Route A was selected as the Proposed Route.
- Route A balances minimizing impacts, paralleling existing infrastructure, and avoiding protected lands.
- It offers the best performance in route length, footprint, and community resources.
- The final route includes ancillary facilities and initial riparian habitat zones to reduce impacts.
- The routing process prioritized safety, cost-effectiveness, and environmental considerations.
- The selected route is the most balanced solution, with no inferior performance compared to other options.