



# MONTANA TRANSMISSION CONNECTIVITY STUDY

## Geospatial Analysis

### Abstract

Supporting information addressing the land use implications of the transmission solutions identified in the Energy Strategies report: "Montana Transmission Connectivity Study: Strategic Roadmap to Enhance Montana's Connection with the West." Montara Mountain Energy used geospatial cost-path optimization (Dijkstra's algorithm) to identify geospatially-explicit routes for the transmission solutions in low-, medium-, and high-environmental impact avoidance scenarios. Several of the transmission options considered for this region would cross some of the steepest most complex terrain in the lower 48 states. Traversing this terrain requires advanced construction techniques and higher-than-typical costs. Geospatial route optimization was applied to help identify routes with terrain advantages, for example following existing linear corridors such as rivers, valleys, roads and existing transmission corridors wherever possible. However, cost premiums for construction in mountainous terrain cannot be avoided altogether.

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## Introduction

The purpose of this document is to provide supporting information addressing the land use implications of the transmission solutions identified in the Energy Strategies report: “Montana Transmission Connectivity Study: Strategic Roadmap to Enhance Montana’s Connection with the West.” The Montana Connectivity study evaluates transmission upgrade options for connectivity between Montana and the Pacific Northwest, under several scenarios: low, medium, and high resource deployment, and low, medium, and high environmental impact avoidance. Energy Strategies identified transmission solutions. Montana used geospatial cost-path optimization (Dijkstra’s algorithm) to identify geospatially explicit routes and evaluate land use implications for the transmission solutions in each scenario. All line routes are hypothetical in nature, and multiple route options are identified for each line. The purpose of the geospatial analysis is to enable location-specific observations about the terrain-based costs, physical feasibility, and potential impacts of the transmission solutions being considered.

Several of the transmission options considered for this region would cross some of the steepest most complex terrain in the lower 48 states, the mountains of northern Idaho. Traversing this terrain requires advanced construction techniques and higher-than-typical costs. Geospatial route optimization was applied to help identify routes with terrain advantages, for example following existing linear corridors such as rivers, valleys, roads and existing transmission corridors wherever possible. However, cost premiums for construction in mountainous terrain cannot be avoided altogether.

The three scenarios (low to high deployment) range in total line length from 400 to 3000 miles, due to increasing amount of infrastructure in each scenario. Altering the line routes to avoid environmentally sensitive areas increases the total line length by approximately 5 percent. It is possible to avoid impacts to several key environmentally sensitive areas such as national parks, monuments, wilderness, wild and scenic rivers, designated endangered species habitat, and wetlands in some places. These findings are extremely sensitive to input assumptions about degrees of environmental sensitivity of certain areas, and they are subject to change based on community input and local knowledge.

The low resource deployment scenario includes only one line: the Townsend to Midpoint line only, with an estimated cost (terrain only<sup>1</sup>) of \$2.7 billion (note costs reported here do not

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<sup>1</sup> While many location-specific factors were incorporated into the route identification process (slope, land cover type such as forest or agricultural land, urban areas, water bodies, environmental sensitivity, existing infrastructure such as airports, wildfire risk, tribal lands, existing transmission Right-Of-Way), the final cost estimates followed the previously identified routes and used only a subset of the factors (slope, land cover type such as forest or

include additional converter stations and other equipment identified in post-processing by Energy Strategies). The medium deployment scenario includes 12 lines. The terrain-based geospatially-routed cost estimates for the medium-deployment scenario is approximately \$7 billion, and there is minimal difference between low environmental impact avoidance to high environmental impact avoidance. The high-deployment scenario includes 15 lines. The terrain-based cost estimates for the high-deployment scenario ranges from \$10.8-11.9 billion (low impact avoidance to high impact avoidance). Throughout this report, most analysis refers to the high-deployment scenario since it encompasses the other two scenarios. This enables a focus for this report on the environmental impact avoidance scenarios (low, medium, high impact avoidance).

The goal of the environmental impact avoidance scenario analysis is to incorporate environmental information into energy planning as early as possible, in order to avoid impacts to the most sensitive places, reduce risk, decrease construction cost and minimize schedule delays associated with siting and permitting processes.

The spatial analysis identified a top few higher-cost lines (on a per-mile basis) in the most complex terrain: New Great Falls-Taft 500kV lines (226% of base cost), New Taft-Hatwai 500kV (157% of base cost), Reconductor Landers Fork-Ovando-Placid Lake 230kV line (152% of base cost). Similarly, the bottom few lower-cost lines (on a per-mile basis) were identified in simpler more open terrain, for example: New Great Falls-Broadview 500kV (123% of base cost), New Bell-Ashe 500kV line (118% of base cost). For the high-impact-avoidance scenario, the geospatial optimization identifies notably distinct alternate routes for the following lines: New Taft-Hatwai 500kV, New Bell-Ashe 500kV line, New Garrison-Little Goose 500kV line, New Colstrip-Townsend HVDC lines. These alternate routes take distinctly different paths from the base case scenario, to avoid impacts to the following key types of environmentally sensitive areas: state park, national forest, conservation easements, and areas with known conservation value, which do not currently have formal protections in place.

## Key Findings

Overall, for this study area, the most mountainous and forested lines are in the western Rockies exiting onto the Columbia Plateau. The restricted terrain causes routes to fall into river valley corridors which may have less technically challenging terrain, but which may be more expensive and perhaps harder to secure for construction rights. There is a trade-off of greenfield transmission on tough terrain vs. co-location or parallel greenfield which may have fewer

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agricultural land, urban areas, water bodies, existing infrastructure such as airports, existing transmission Right-Of-Way). This is because several of the factors present potential siting, permitting, and schedule challenges which are not directly quantifiable in terms of construction cost.

technical costs but which may entail more land ownership negotiation and potential contracting challenges.

With respect to cost, we see that increasing environmental protections only leads to small increases in costs; however, at the same time it also illustrates that cost isn't the only metric that should be considered and that perhaps a more advanced approach measuring of 'friction' may be required to get a better understanding of where lines could be built that are least cost and least environmentally damaging. In some cases, sub-optimal routes may be most viable.

Wind and solar resource availability (suitable land) in proximity to lines is more than adequate to support the high-deployment scenario even under high restriction scenarios (which avoid impacts to cores/corridors and high-conflict solar siting challenges). The results show there is abundance in Montana but that there is also still some capacity in Eastern Washington (though it is reduced). Transmission and development can occur in these areas even while avoiding impacts to the most sensitive places, and in a way that is responsive to the concerns of farming, ranching, and conservation communities.

## Approach

In order to perform geospatial analysis for line route identification, and optimization, the following location-specific terrain factors were considered: slope, land cover type such as forest or agricultural land, urban areas, water bodies, environmental sensitivity, existing infrastructure such as airports, wildfire risk, tribal lands, existing transmission Right-Of-Way. For each terrain type, GIS data were gathered and aggregated. These disparate datasets were standardized into a consistent format (raster with 250 m grid cells and USGS Albers Equal Area conic projection). For each data layer a cost multiplier was assigned, corresponding to typical difficulty of construction in that type of terrain, based on literature including MISO, WECC, and EPRI-GTC methods for transmission path optimization. The terrain datasets were combined into a transmission routing cost surface. For each point-to-point connection (identified by Energy Strategies), three optimal-cost-path routes were identified, corresponding to low, medium, and high levels of environmental impact avoidance across the cost surfaces. The identification of environmentally sensitive areas was based on multiple data sources, including WECC Environmental Risk Class Data, The Nature Conservancy Power of Place study, the Washington State University Least Conflict Solar Siting Study for the Washington Columbia Plateau, and WAHCAP Cores and Corridors. For more information regarding treatment of individual data sources, see Appendices.

For an illustration of three different line route options representing low, medium, and high environmental impact avoidance, see Figure 1 below.

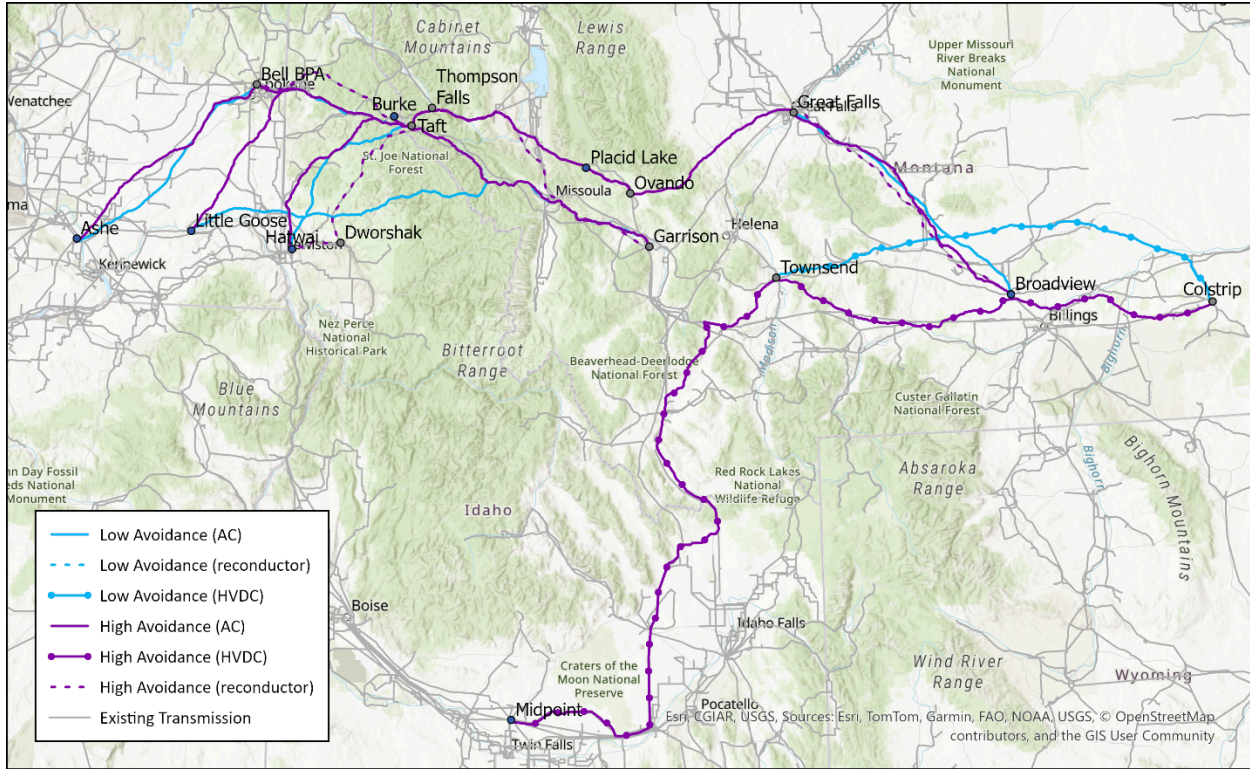


Figure 1. Overview of all lines, high-deployment scenario, low- and high- environmental-impact-avoidance scenarios.

# Results

The following sections summarize high-level findings with respect to a variety of terrain factors: mountainous terrain, land cover type, high-value real estate, environmental sensitivity, reconductoring, existing right-of-way corridors, river crossings, road crossings, wildfire risk, federal land, proximity of land meeting wind power site suitability criteria, and tribal land.

## Mountainous terrain

For the high deployment scenario, there are 600 to 700 miles of mountainous terrain crossed (26-27% of total line length). Upgrades with the greatest mountainous terrain appear at the top of Table 1 (69-86%). Mountainous terrain may pose construction challenges for these lines in particular. All remaining lines have less than 67% mountainous, with several lines having less than 10% mountainous.

*Table 1. Top few lines with mountainous terrain*

Name	Percent Mountainous
Dworshak to Hatwai 500 kV Reconductor	86%
Thomson Falls to Burke 115 kV Reconductor	86%
Taft to Dworshak 500 kV Reconductor	69%
Taft to Bell Reconductor 500kV Reconductor	67%
Taft to Hatwai 500 kV New Line	51%
Taft to Bell 500 kV New Line	44%
Ovando to Placid Lake 230 kV Reconductor	38%
Great Falls to Taft 500 kV New Line	33%
Garrison to Little Goose 500 kV New Line	32%
Townsend to Midpoint 500 kV Reconductor	18%
Colstrip to Townsend 500 kV New Line	12%
Great Falls to Broadview 230 kV Reconductor	8%
Great Falls to Broadview 500 kV New Line	2%
Bell to Ashe 500 kV New Line	1%
Townsend to Midpoint 500 kV New Line	0%

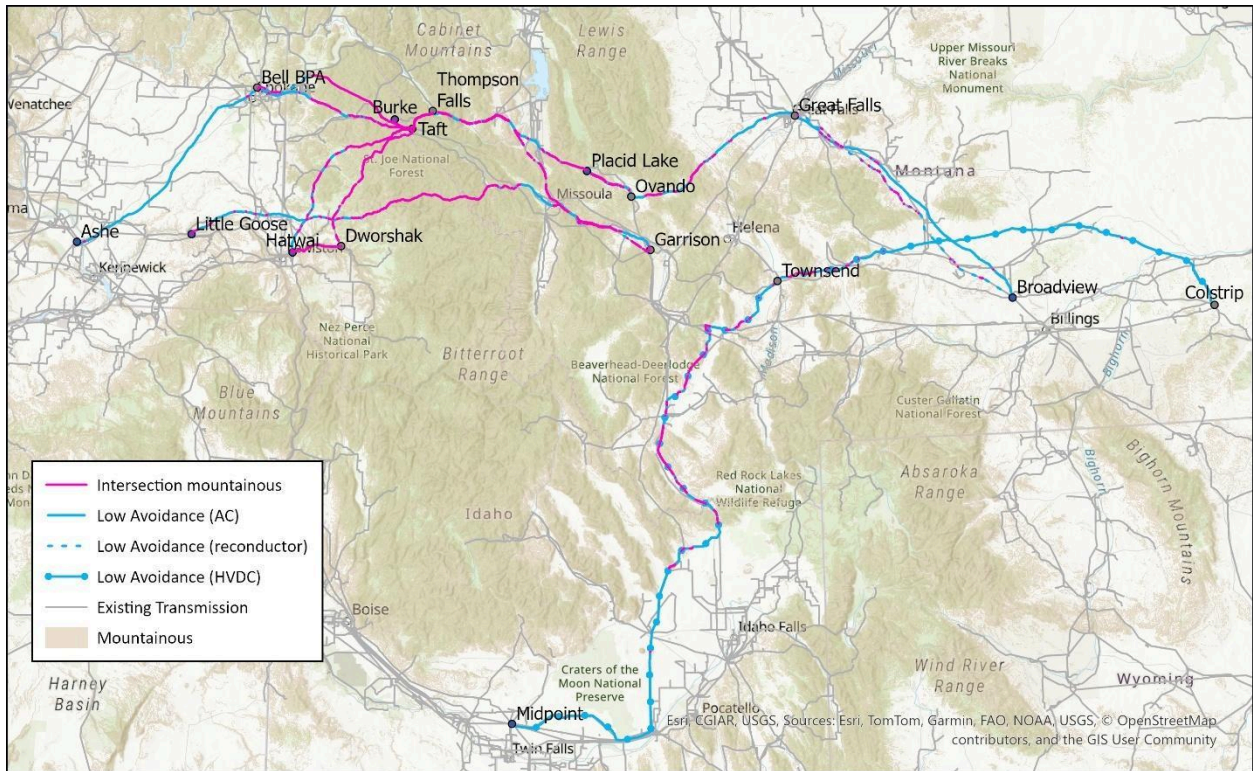


Figure 2. Highlighted segments crossing mountainous terrain

## Land Cover Type

For the high deployment scenario, there are 2300 miles of forested terrain crossed (med avoidance). Forest land cover may pose construction challenges for the top three lines in Table 2. All remaining lines have less than 36% forested, with five lines having less than 1% forested.

Table 2. Top few lines crossing forested terrain

Name	Percent Forested
Taft to Bell 500 kV New Line	81%
Thomspen Falls to Burke 115 kV Reconductor	66%
Taft to Dworshak 500 kV Reconductor	48%
Ovando to Placid Lake 230 kV Reconductor	36%
Great Falls to Taft 500 kV New Line	19%
Taft to Hatwai 500 kV New Line	17%
Garrison to Little Goose 500 kV New Line	11%
Dworshak to Hatwai 500 kV Reconductor	7%
Townsend to Midpoint 500 kV New Line	1%
Colstrip to Townsend 500 kV New Line	1%
Great Falls to Broadview 230 kV Reconductor	1%
Great Falls to Broadview 500 kV New Line	0%
Bell to Ashe 500 kV New Line	0%
Taft to Bell 500kV Reconductor	0%

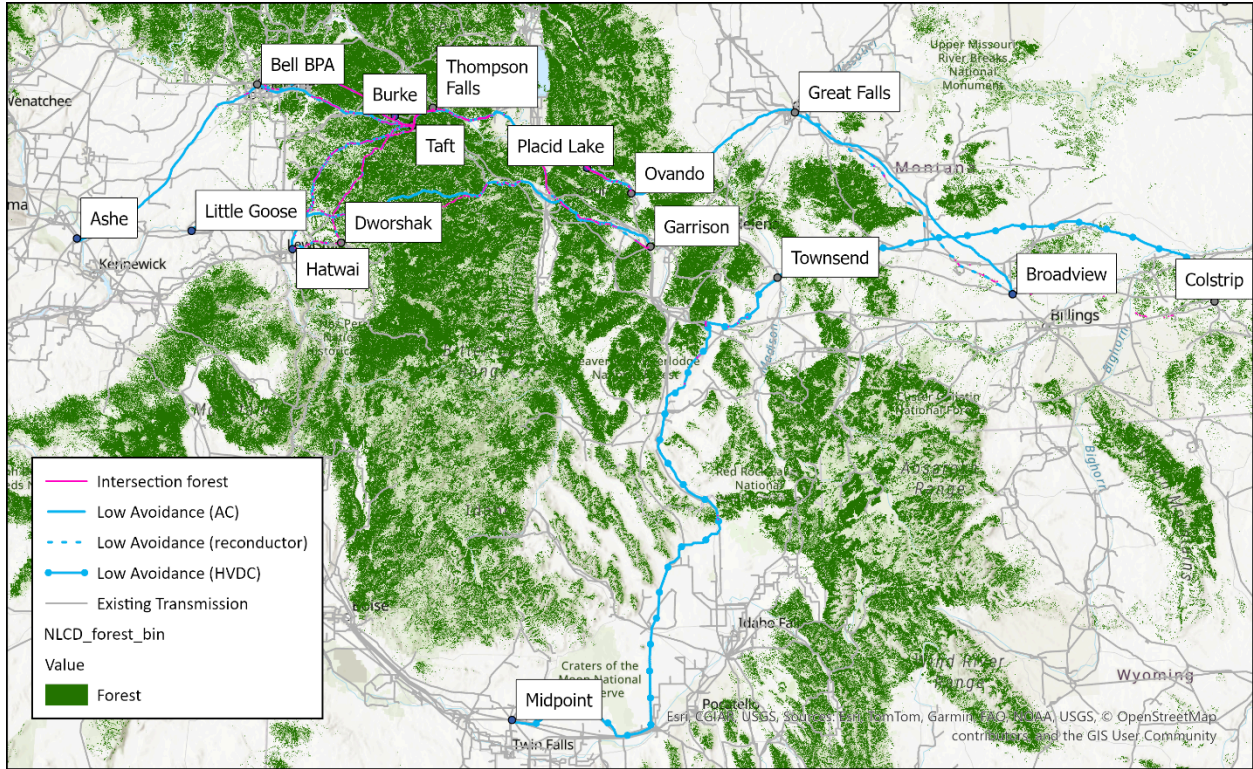


Figure 3. Highlighted segments crossing forested terrain

### High-Value Real Estate

For the high deployment scenario, there are approximately 450 miles occurring on high-fair-market-value real estate. Lines particularly affected by high real estate value (top quartile in the study area) appear at the top of Table 3.

Table 3. Top few lines on high-market-value land

Name	Percent High FMV
Taft to Bell 500 kV New Line	100%
Taft to Bell Reconductor 500kV Reconductor	100%
Ovando to Placid Lake 230 kV Reconductor	64%
Great Falls to Taft 500 kV New Line	51%
Garrison to Little Goose 500 kV New Line	36%
Bell to Ashe 500 kV New Line	27%
Townsend to Midpoint 500 kV New Line	24%
Thomson Falls to Burke 115 kV Reconductor	16%

Dworshak to Hatwai 500 kV Reconductor	15%
Taft to Hatwai 500 kV New Line	9%
Colstrip to Townsend 500 kV New Line	9%
Great Falls to Broadview 500 kV New Line	8%
Great Falls to Broadview 230 kV Reconductor	3%
Taft to Dworshak 500 kV Reconductor	3%

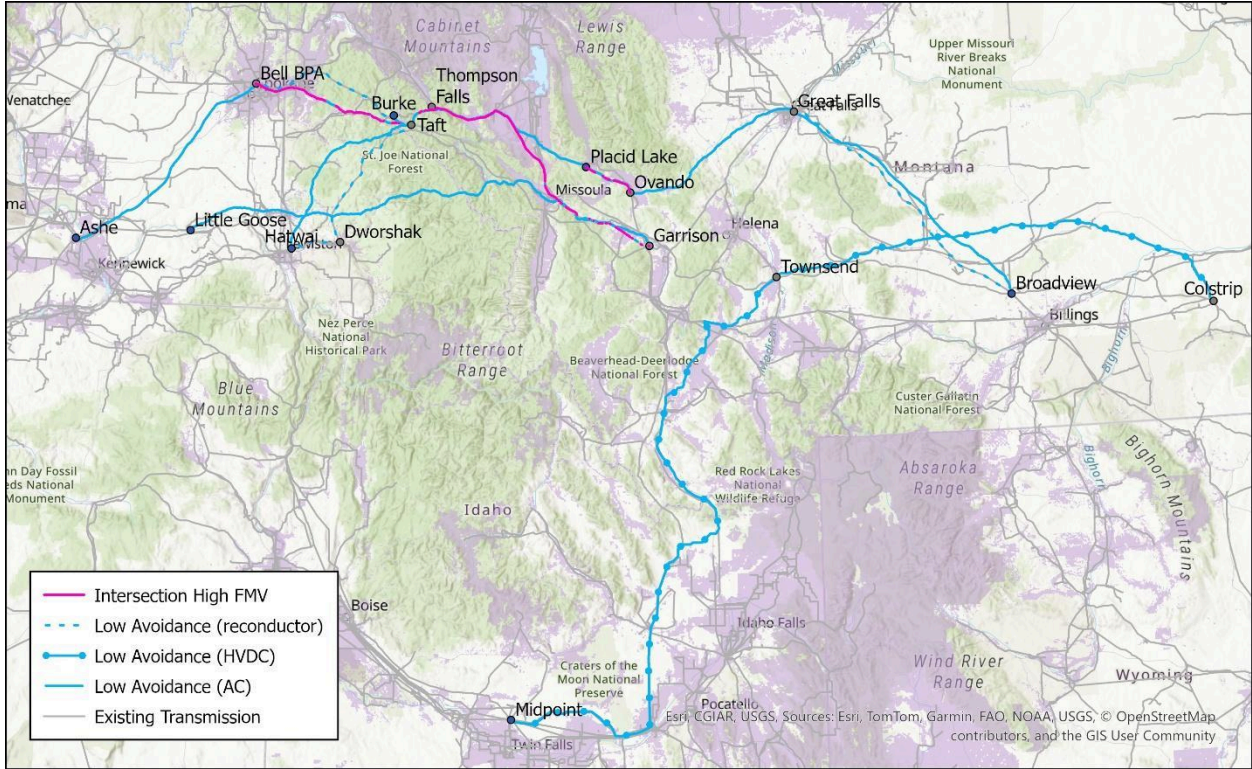


Figure 4. Highlighted segments occurring on high-value-land

## Environmental Sensitivity

For the high deployment scenario, there are approximately 70 miles occurring on high-environmental-sensitivity lands. Lines particularly affected by high environmental sensitivity (Nature Conservancy Power of Place Category 1, considered high risk by WECC, and corresponding to USGS GAP Status 1) are Ovando to Placid Lake (57%) and Great Falls to Taft (11%). All other new AC lines have less than 3% of their corridors in high-environmental-risk areas.

Table 4. Summary of environmentally sensitive area affected for low and high avoidance scenarios

Type	Low Avoidance Scenario (mi)	High Avoidance Scenario (mi)	Percent Change
High Environmental Sensitivity area affected	83	80	0%
Medium Environmental Sensitivity area affected	1,237	977	-2%
Low-Moderate Environmental Sensitivity area affected	1,708	1,517	-4%

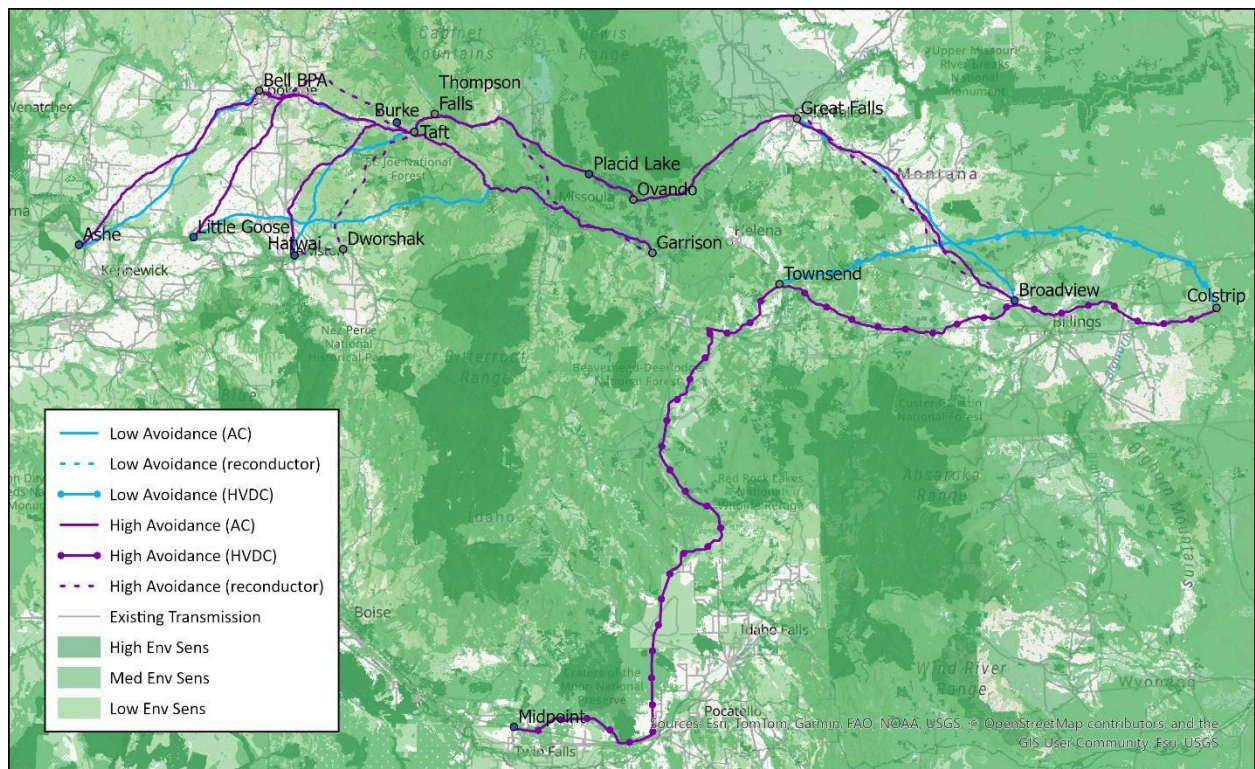


Figure 5. All paths overlaid with environmentally sensitive areas

## Reconductoring

Reconductoring with standard technology conductors (ACSR for example) can tend to reduce cost by 50% as compared to new line with same technology; however, reconductor projects still face terrain-based cost increases where mountains and forest occur. Reconductoring to replace current technology with advanced conductors can bring cost increase rather than savings. In cases where the reconductoring results in a higher-voltage line rating than existing conditions, then the right-of-way width must be increased and thus land acquisition is not avoided. This does not significantly change the findings because right-of-way cost tends to be relatively small, in the range of 5% of overall project cost for a new transmission line.

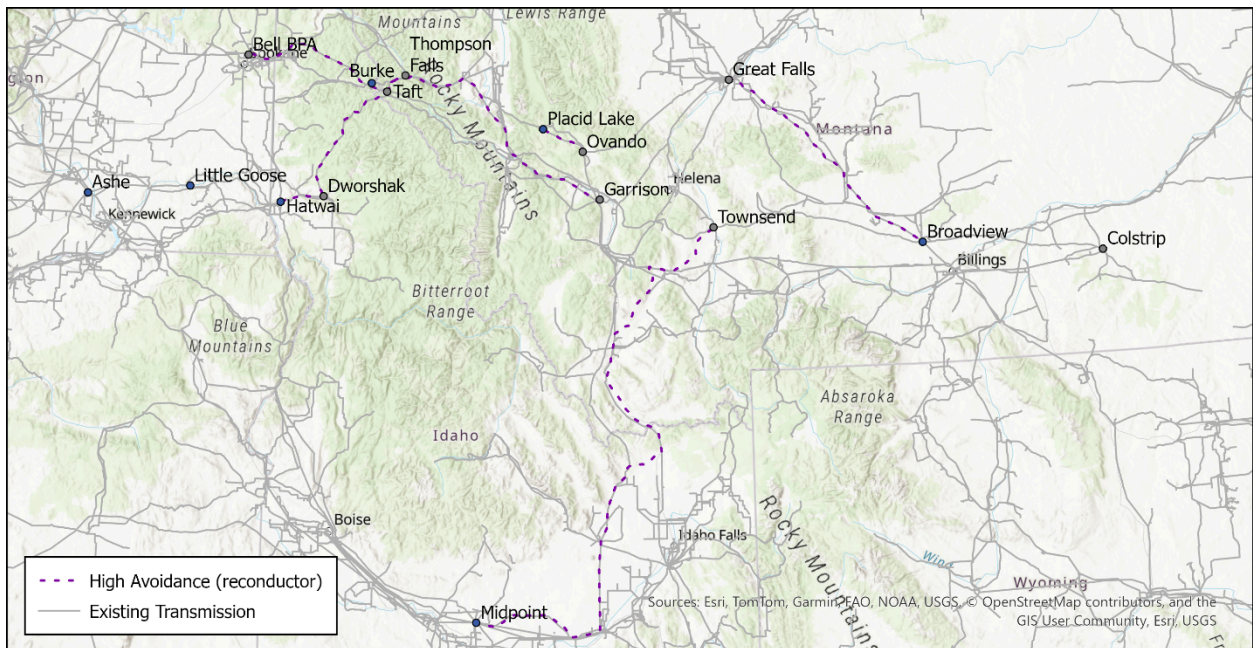


Figure 6. Reconductor projects can save approximately 50% cost compared to new lines. Land acquisition costs are reduced but not eliminated. Terrain and land use challenges remain for both new and reconductor project types.

## Existing Right-of-Way Corridors

There are 854 mi where new line routes occurring within 1 km of existing transmission corridors. Negotiating with diverse transmission owners across multiple balancing areas can be a complex task. Lines in existing transmission corridors have many owners. For example the Townsend to Midpoint project is co-located with the following existing transmission line segments: Midpoint to Adelaide (Idaho Power Company): 345 kV, TAP203129 to Borah (IPCO) 345 kV, Brady to Antelope (IPCO) 230 kV, Amps to Antelope (PacifiCorp) 230 kV, Amps to Mill Creek (Northwestern Energy) 230 kV, Garrison to Anaconda (Bonneville Power) 230 kV, Garrison to Broadview (BPA) 500 kV.

*Table 5. Lines with percent of length occurring within 1 km of existing corridors*

Name	Percent w/in 1 km Existing Transmission (New Lines Only)
Great Falls to Taft	100%
Taft to Bell	85%
Garrison to Little Goose	64%
Townsend to Midpoint	58%
Great Falls to Broadview	50%
Taft to Hatwai	39%
Bell to Ashe	38%
Colstrip to Townsend	23%
Reconductor projects	100%



Figure 7. Top three lines with greatest segments within 1 km of existing transmission corridor

### River Crossings

It is important to note that the river and road crossing analysis specifically, the following limitations apply: small geospatial routing/cost changes can cause a shift in direction of a route which may then drive river crossings (especially pertinent if it is already paralleling the river or road). Nevertheless, a high-level count of the total number of rivers crossed can provide indicative characterization of the terrain.

The lines at the top of Table 6 have more than 30% within 1 km of a river corridor. All other lines have less than 25%. In the route optimization, a 130% cost multiplier was applied for segments crossing bodies of water. However, it is important to recognize the limitations of the geospatial cost optimization process. Siting and permitting challenges may occur affecting construction schedules and overall project feasibility, beyond those captured in simple cost-benefit analysis.

Table 6. Top three lines with greatest river crossings

Name	Rivers Crossed	Count	Percent within 1km River
Ovando to Placid Lake 230 kV Reconductor	Clearwater River	1	52%
Garrison to Little Goose 500 kV New Line	North Fork Clearwater River, Potlatch River, Clark Fork, Blackfoot River	4	32%
Great Falls to Taft 500 kV New Line	Clark Fork, Clearwater River, Flathead River, Little Bitterroot River, Blackfoot River, Thompson River, Dearborn River, Sun River	7	24%
Taft to Dworshak 500 kV Reconductor	Saint Joe River, Saint Regis River	2	12%
Taft to Bell 500 kV New Line	Coeur d'Alene River, Coeur d'Alene River	1	11%
Dworshak to Hatwai 500 kV Reconductor	Clark Fork	1	11%
Great Falls to Broadview 500 kV New Line	Missouri River, Fish Creek, Judith River, Belt Creek, Surprise Creek, Sage Creek, Musselshell River	7	8%
Great Falls to Broadview 230 kV Reconductor	Missouri River, Fish Creek, Judith River, Belt Creek, Surprise Creek, Sage Creek, Musselshell River	7	8%
Taft to Hatwai 500 kV New Line	Saint Joe River, Saint Maries River, Saint Regis River	3	7%
Townsend to Midpoint 500 kV New Line	Missouri River, Boulder River, Red Rock River, Medicine Lodge Creek, Big Lost River, Birch Creek, Beaverhead River, Big Hole River	8	5%
Colstrip to Townsend 500 kV New Line	Tulloch Creek, Sarpy Creek, Bighorn River, Fish Creek, Yellowstone River, Musselshell River	6	5%
Thomson Falls to Burke 115 kV Reconductor	Clark Fork	1	4%
Bell to Ashe 500 kV New Line	Spokane River, Columbia River	2	3%



Figure 8. Highlighted river crossings

## Road Crossings

The following lines cross more than 5 major roads. All other lines cross fewer than 5 roads. No cost multiplier was applied for road crossings. Nevertheless, road crossings may present siting and permitting challenges beyond those captured in simple cost-benefit analysis.

Table 7. Top few lines with greatest road crossings

Name	Roads Crossed	Count	Percent within 1km Existing Road
Taft to Bell 500 kV New Line	I- 90, US Hwy 95, US Hwy 95	3	62%
Garrison to Little Goose 500 kV New Line	I- 90, US Hwy 12, US Hwy 195, US Hwy 93, US Hwy 95, I- 90, US Hwy 12	7	44%
Great Falls to Broadview 500 kV New Line	US Hwy 12, US Hwy 191, US Hwy 87	3	19%
Bell to Ashe 500 kV New Line	I- 90, US Hwy 2, State Rte 17, US Hwy 2, US Hwy 395	5	12%
Townsend to Midpoint 500 kV New Line	I- 15, I- 90, US Hwy 287, State Hwy 33, US Hwy 26, US Hwy 20	6	9%
Colstrip to Townsend 500 kV New Line	I- 94, US Hwy 12, US Hwy 191, US Hwy 87, US Hwy 89	5	5%
Great Falls to Taft 500 kV New Line	US Hwy 287, US Hwy 87, US Hwy 93, I- 15, US Hwy 89	5	4%
Thomspon Falls to Burke 115 kV Reconductor	none	0	4%
Taft to Dworshak 500 kV Reconductor	I- 90	1	2%
Taft to Hatwai 500 kV New Line	I- 90	1	1%
Ovando to Placid Lake 230 kV Reconductor	none	0	0%

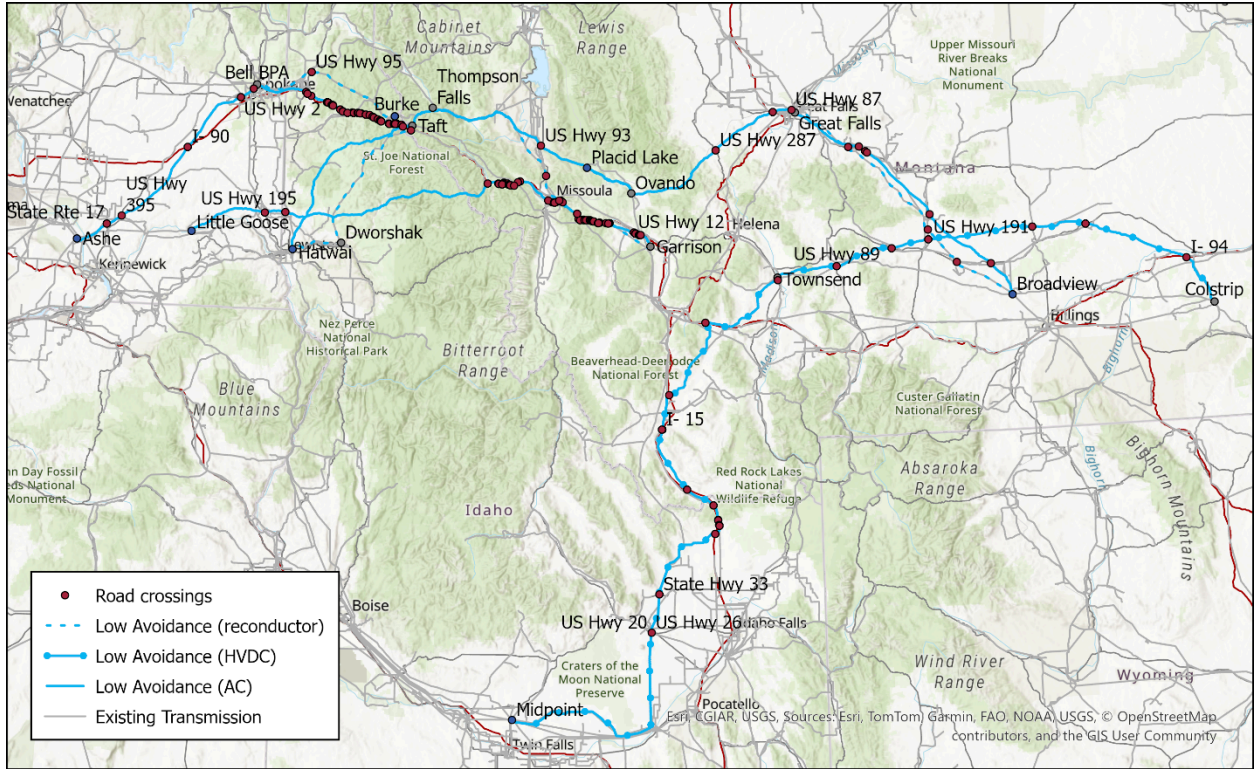


Figure 9. Highlighted road crossings

## Wildfire Risk

There are 394 miles high-wildfire risk corridors affected. The top three lines in Table 8 have greater than 33% in high wildfire risk areas. The remaining lines have less than 33%. Studies show increasing frequency and magnitude of wildfires in the western U.S. Electric transmission-related ignition is an issue of increasing concern. Many transmission owners are applying fire-hardening measures to the landscape in transmission corridors, and undertaking monitoring measures with increased frequency, and implementing public safety related shutoffs during highest-fire-risk days of the year.

Table 8. Top few lines with greatest wildfire risk

Name	High Wildfire Risk
Ovando to Placid Lake 230 kV Reconductor	86%
Dworshak to Hatwai 500 kV Reconductor	53%
Townsend to Midpoint 500 kV New Line	38%
Garrison to Little Goose 500 kV New Line	33%
Great Falls to Taft 500 kV New Line	32%
Thomson Falls to Burke 115 kV Reconductor	13%
Taft to Dworshak 500 kV Reconductor	12%
Colstrip to Townsend 500 kV New Line	10%
Bell to Ashe 500 kV New Line	6%
Taft to Bell 500 kV New Line	0%
Great Falls to Broadview 500 kV New Line	0%
Taft to Hatwai 500 kV New Line	0%
Taft to Bell Reconductor 500kV Reconductor	0%
Great Falls to Broadview 230 kV Reconductor	0%

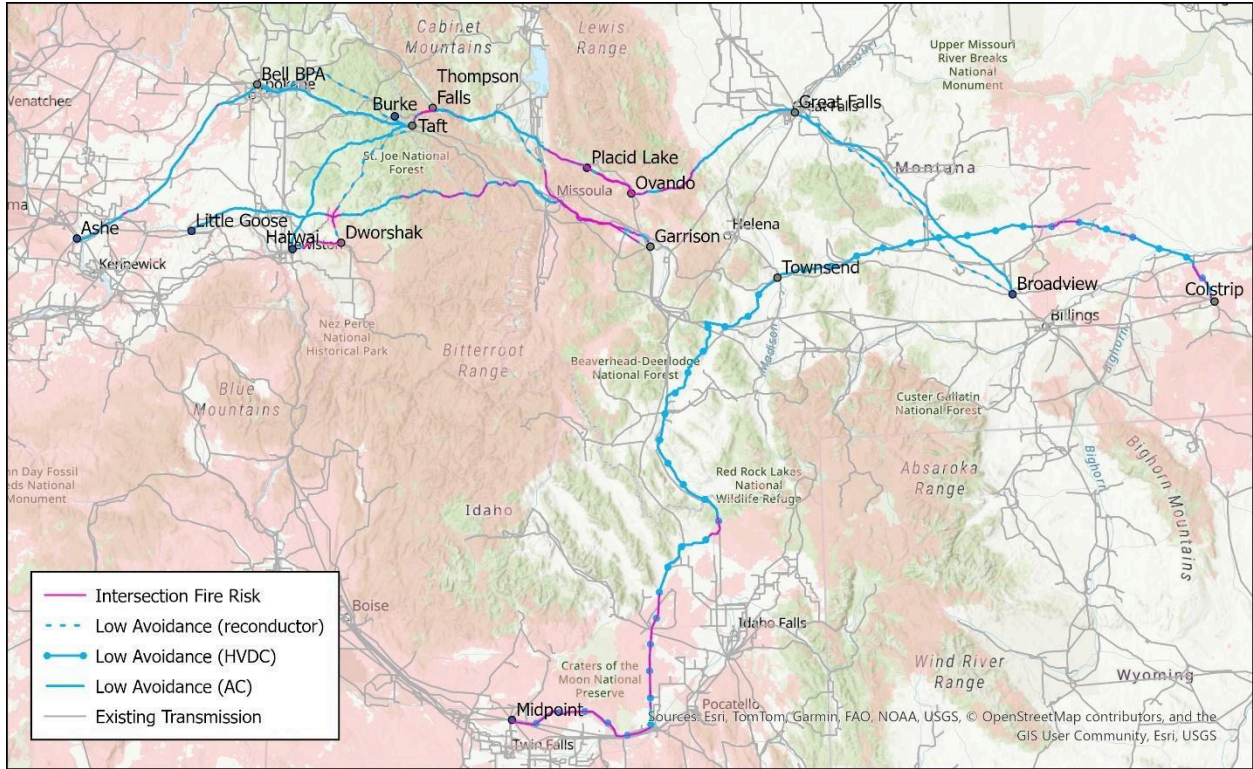


Figure 10. Highlighted segments with greatest wildfire risk

### Federal Land

For the high deployment scenario, there are approximately 600 miles occurring on federal lands. Lines particularly affected by federal land appear at the top of Table 9. All remaining lines have less than 54% federal land.

At the time of this writing, the processes for siting and permitting infrastructure projects on federal land are changing,<sup>2</sup> presenting challenges to wind and solar project siting. While this report makes no prediction of the relative ease or difficulty of new transmission on federal land, it provides a high-level indication of the amount of federal land affected for each line.

Table 9. Top few lines with greatest federal land

Name	Federal Land
Taft to Bell 500 kV New Line	74%
Thompson Falls to Burke 115 kV Reconductor	69%
Townsend to Midpoint 500 kV New Line	54%
Taft to Dworshak 500 kV Reconductor	42%

2

<https://www.doi.gov/pressreleases/secretary-burgum-announces-order-rein-environmentally-damaging-wind-and-solar>

Taft to Hatwai 500 kV New Line	32%
Garrison to Little Goose 500 kV New Line	19%
Great Falls to Taft 500 kV New Line	11%
Ovando to Placid Lake 230 kV Reconductor	7%
Bell to Ashe 500 kV New Line	5%
Colstrip to Townsend 500 kV New Line	4%
Great Falls to Broadview 500 kV New Line	2%
Taft to Bell Reconductor 500kV Reconductor	0%
Great Falls to Broadview 230 kV Reconductor	0%
Dworshak to Hatwai 500 kV Reconductor	0%

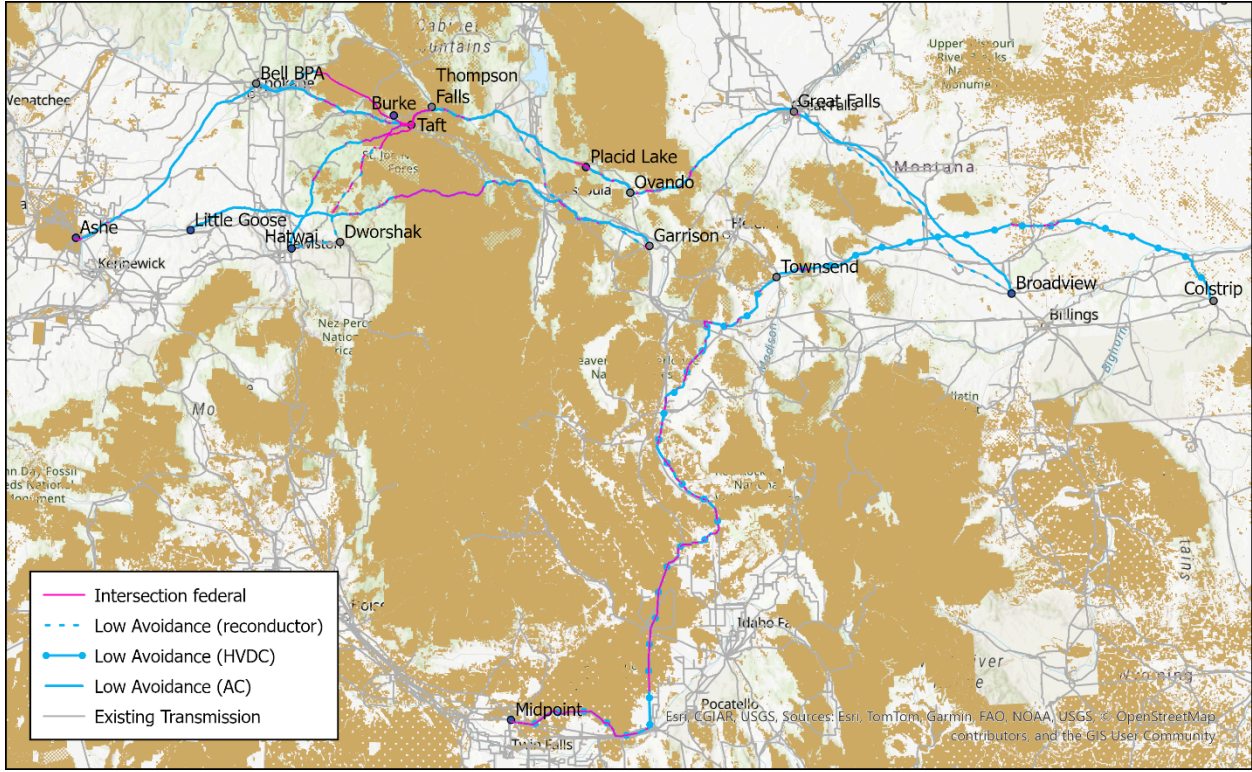


Figure 11. Highlighted segments with greatest federal land

### Wind Power Site Suitability: Candidate Project Areas

Overall the total amount of land that meets site suitability criteria for wind development is 71 to 152 GW (low avoidance, 5-15 mi radius) and 29-58 GW (high avoidance, 5-15 mi radius).

Even under more restrictive low-impact scenarios there are significant wind resources in close proximity to lines in the Broadview-Great Falls corridor as well as near Townsend and Midpoint. In particular, there are high levels of low-impact resources along the Montana Idaho intertie

that could be served by this line. In less restrictive scenarios these values are increased even further with Montana offering 49 GW of potential capacity within 5 miles of proposed routes. This reinforces the value of the Montana-Idaho intertie as there are not only adequate resources on both nodal ends of the route but also along most of its path as well. There are high amounts of proximal capacity along proposed Colstrip lines.

On the Washington side of the proposed routes, higher environmental restrictions largely reduce potential capacity. With relaxed constraints (high impact) the Bell-Ashe line has several gigawatts of potential wind resources within 5 miles throughout most of its route. Similarly the Garrison-Little Goose and Taft-Hatwai lines also host large amounts of wind potential within 5 to 10 miles of the western parts of the routes (near Pullman). However if other lines in the portfolios were not built, despite these routes potentially unlocking some wind resources, it is unclear if they would provide line capacity in the right direction to justify development. Additionally, with restrictions seeking to lower impact, wind capacity potential drops heavily in Washington with only around 2 GW remaining within 10 miles of the Bell-Ashe line near Spokane, and none on the other route segments. In conclusion, under the high deployment scenario, with either low or high levels of impact avoidance, there is some potential for wind development along the Bell-Ashe line; while loosening restrictions brings up to 6 GW of wind with 5 miles of lines to Washington.

Table 10. Total Wind Resource Potential within 5, 10, and 15 mi of hypothetical transmission lines in high-deployment scenario.

Low Impact Avoidance (GW)					High Impact Avoidance (GW)				
Distance	Washington	Idaho	Montana	Total	Distance	Washington	Idaho	Montana	Total
5 Miles	6	16	49	<b>71</b>	5 Miles	1	6	22	<b>29</b>
10 Miles	11	25	77	<b>113</b>	10 Miles	2	9	32	<b>43</b>
15 Miles	16	33	103	<b>152</b>	15 Miles	3	13	42	<b>58</b>

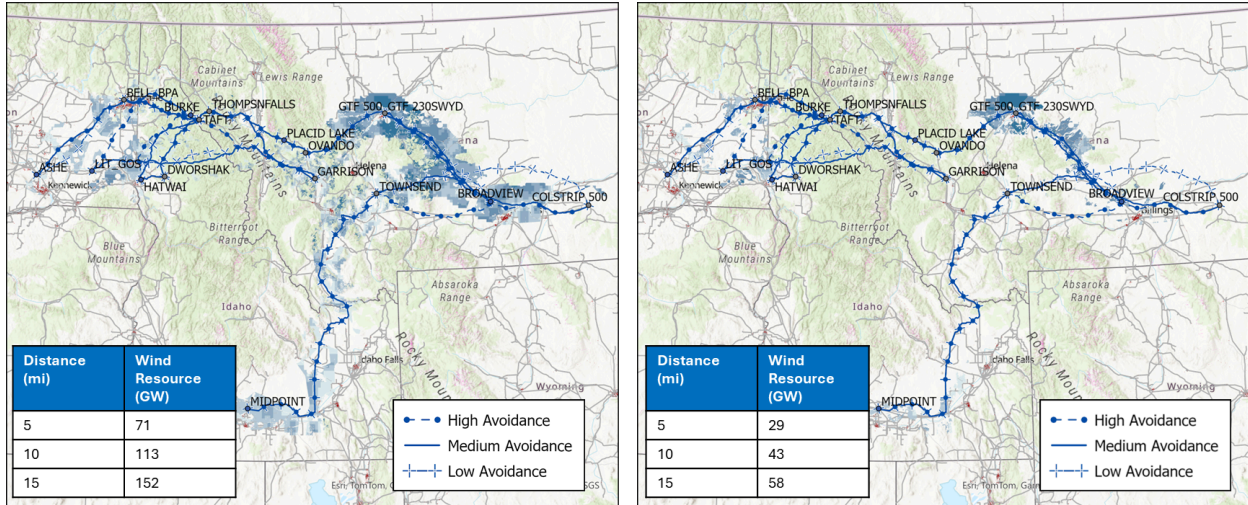


Figure 12. Total wind resource potential within 5, 10, and 15 mi of hypothetical transmission lines in high-deployment scenario (Low Avoidance – left. High Avoidance – right.)

## Tribal lands

A cost multiplier was assigned to tribal lands as part of the development of the cost surface, to ensure that the optimal route options would avoid tribal lands to the extent possible. Native American Indian reservation lands were identified based on the American Indian Alaska Native and Native Hawaiian Areas identified in the USGS Protected Areas of the US.

There are two main places where possible tribal land crossings might occur: the Flathead Indian Reservation (New Great Falls-Taft 500kV line) and the New Perce Reservation (Reconductor Dworshak-Hatwai 500kV reconductor). For the Great Falls to Taft line, the optimal cost path would cross the Flathead reservation. However, an alternate route option was identified which avoids the Flathead reservation altogether. See Figure 2 below.



Figure 13. Tribal land avoidance alternative, Great Falls to Taft

The blue line in the figure above is preferred for electrical reliability reasons; the green line avoids tribal lands but might be more likely to cause reliability issues. Further information and discussion is needed to ensure stakeholder input is incorporated.

For the Dworshak to Hatwai 500 kV line, because it is a reconductor project, with both end points located on the Nez Perce reservation, it was not possible to identify an alternate route to avoid the reservation altogether.

Further engagement with tribal representatives is needed to develop understanding and corresponding data regarding corridor options and preferences in this region. An appropriate starting point may be the three data layers from the WECC Regional Transmission Expansion Planning program: Cultural Risk, Inventory Areas; and Neighborhood Site Density. An appropriate process might be informed by the approach taken in the evaluation of potential transmission corridors for offshore wind on land in California by Aspen Environmental (2024). In this approach, each corridor segment is evaluated for the percentage of tribal lands within the segment or within 5 miles of the segment boundaries.

## Conclusion

Transmission solution identification requires complex and multi-faceted analysis, incorporating techno-economic, electrical and geospatial data, accounting for a wide range of variables simultaneously. In many cases, a solution that alleviates one type of development pressure brings an increase in other types of pressures. To make the analysis tractable, simplifying assumptions are necessary. Recent advances in analytical techniques have improved our ability to account for multiple factors simultaneously. This study illustrates advances toward more integrated solutions with multiple benefits to the system and to the landscape as a whole.

Overall, for this study area, the most mountainous and forested lines are in the western Rockies exiting onto the Columbia Plateau. The restricted terrain causes routes to fall into river valley corridors which may have less technically challenging terrain, but which may be more expensive and perhaps harder to secure for construction rights. There is a trade-off of greenfield transmission on difficult terrain vs. co-location or parallel greenfield which may have fewer technical costs but which may entail more land ownership negotiation challenges.

With respect to cost, we see that increasing environmental protections only leads to small increases in costs; however, cost isn't the only metric that should be considered and perhaps some sort of measuring of 'friction' may be required to get a better understanding of where lines could be built that are least cost and least environmentally damaging. In some cases, sub-optimal routes may be most viable.

Wind and solar resource availability in proximity to lines is more than adequate to support the high-deployment scenario even under high restriction scenarios (which avoid impacts to cores/corridors and high-conflict areas for conservation, farmland, and rangeland). The results show there is abundance of wind resource potential in Montana but that there is also still some capacity in Eastern Washington (though it is reduced). Transmission and development can occur in these areas even while avoiding impacts to the most sensitive places, and in a way that is responsive to the concerns of farming, ranching, and conservation communities.

## References

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## Appendix A: Transmission routing analysis overview

1. Gather data, pre-processing terrain multipliers, based on historical and emergent challenges to transmission siting, construction, and maintenance.
2. Gather publicly available per-distance cost values for each line type (greenfield/reconductor/co-locate/hvdc etc.) and voltage
3. Prepare unitless cost-raster that accounts for both technical terrain multipliers in addition to specified environmental avoidance multiplier suite.
4. Determine most optimal route between start and end nodes using unitless cost raster (accounting for environmental multipliers).
5. Use per-distance base costs to calculate the technical/terrain only cost of each optimal line
6. Convert line features to corridor features; calculate impacted areas within corridors

### Environmental sensitivity analysis overview:

1. Repeat steps 3-6 above, applying different levels of environmental impact avoidance each time
  - a. Low impact avoidance
  - b. Medium impact avoidance
  - c. High impact avoidance
2. Calculate differences in impacted areas for each type
3. Environmental sensitivity is thus fully integrated into the line route, but the line cost consists only of technical and terrain costs with solid empirical basis.

### Transmission routing, Step 1: Preprocessing

- Pre-process input datasets characterizing terrain
- Input dataset sources based on recommendations from literature (Houston et al 2006)
- Specifications for pre-processing:
  - All input datasets converted to consistent format
    - 250x250m cell size

- NAD1983 Albers equal area conic coordinate system, central meridian -114
- Snap to consistent grid
- Binary values (1 where terrain type is present, and no data where terrain type is not present)
- Use template raster to standardize
  - Template raster should include study area AND areas outside study area for anomalous features
- Template may also include a buffer zone to discourage pathing errors out of study area
- Create inputs for the unitless; comprised of 3 sub-categories:
  - Terrain multipliers: These are strictly land based multipliers that impact the technical cost for line development
  - Environmental multipliers: These represent the conservation and environmental priorities outlined in Power of Place and updated with project specific additions outlined by stakeholders see Appendix B.
  - Right of Way multipliers: These simple corridors are built around existing transmission lines with a 265m buffer (to allow continuity through a 250m resolution raster) and are used to distinguish between 1) line types that **adhere to** existing Right-Of-Way (ROW), and 2) line types that **avoid** existing ROW
    - For line types that adhere to existing ROW (reconductor and co-locate), set cell values outside ROW = 10X base values
    - For line types that avoid existing ROW (new greenfield lines), set cell values inside ROW = 10X base values

Transmission routing, Step 2: Base Cost Preprocessing

- Gather standard base costs that encompass total cost of development per distance (usually \$/mile)
- Convert costs to raster resolution (meters)
- Ensure base costs exist for all given configurations of line type and voltage
- Add additional costs based on requirements like advanced or high-capacity conductors.

#### Transmission routing, Step 3: Prepare Unitless Cost Raster

- The inputs identified in step 1 are combined to form the unitless cost raster for each environmental sensitivity regime as well as the colocation and reconductor suite (which does not change under environmental conditions due to constraint of following existing lines).
- General raster standardization notes:
  - Assign multiplier value to each set of values in input rasters (1.1 – 5x)
  - Use map algebra with the following equation
    - $\text{Multipliers\_combined} = \text{inraster\_multiplier\_1} * \text{inras\_multiplier\_2} * \text{inras\_multiplier\_3} * \dots$
  - For cells where no terrain multiplier is present, assign value = 1
  - For cells outside study area, assign value = 1000 (to deter the optimal path from running outside the study area)
- Raster can now be used to find optimal routes that minimize cost while considering environmental, conservation, or any other priorities established in the environmental multipliers.

#### Transmission routing, Step 4: Determine Optimal Route

- Import list of transmission upgrade source-destination point-pairs and types
- Create separate sub-list new lines (greenfield) and reconductor/co-locate lines which do not require to be re-run under different environmental sensitivity regimes.

- For each new line:
  - Determine environmental avoidance unitless cost raster to use
  - Calculate distance and back direction rasters using start and end points
  - Calculate optimal path
- For each co-locate/reconductor line:
  - Select the generic reconductor/co-locate unitless cost raster
  - Calculate distance and back direction rasters using start and end points
  - Calculate optimal path
- Merge poly lines together into single feature class by environmental sensitivity and combine all reconductor/co-locate into single feature as well.
- All feature classes saved in a single geodatabase by environmental impact, with their reconductor/co-locate lines also contained within.

#### Transmission routing, Step 5: Calculate Technical Cost

- Use per-distance costs associated with each line type and voltage
- Combine per-distance costs with terrain multipliers *only* to attain the technical cost for constructing the optimal line identified in step 4:
  - $\text{Cell\_value} = \text{base\_cost}(\$/\text{m}) * \text{terrain\_technical\_multiplier}^*$
- Cell values are then intersected with portion of line that crosses that cell, multiplied by the length of intersection, and iterated across the entirety of the line to produce a total line technical cost that is influenced by terrain multipliers only.
- Cost assumptions based on MISO per-unit costs

#### Transmission routing, Step 6: Calculate impacted areas

- Identify datasets to be used as impact metrics: forest, wetland, high wildfire risk areas, steeply sloped, water bodies, roads, for example
- Buffer transmission lines to create corridor feature class (polygons)

- Corridor width is kept static at 250m to maintain uniformity across all lines given lack of empirical data on existing ROW widths.
- Calculate zonal statistics: summarize area of each impact metric in each corridor, or calculate the area weighted cost (for fair land value)

#### Environmental Sensitivity Analysis:

- Perform steps 3-6 above three times (low impact avoidance, medium impact avoidance, high impact avoidance scenarios).
  - For steps 3: new cost surfaces are created based on the conservation datasets used (See Appendix B)
  - For the “low avoidance” scenario, low multiplier values are assigned to all three types of environmentally sensitive areas.
  - For “medium avoidance” scenario, medium multiplier values are assigned to all three types of environmentally sensitive areas.
  - High avoidance scenario follows same pattern
- Calculate differences in impacted area from the reference scenario for each level of impact avoidance
- Transmission route is thus influenced by environmental/conservation factors, but the line cost itself remains a product of technical considerations only, ensuring total path costs can be compared on a consistent basis

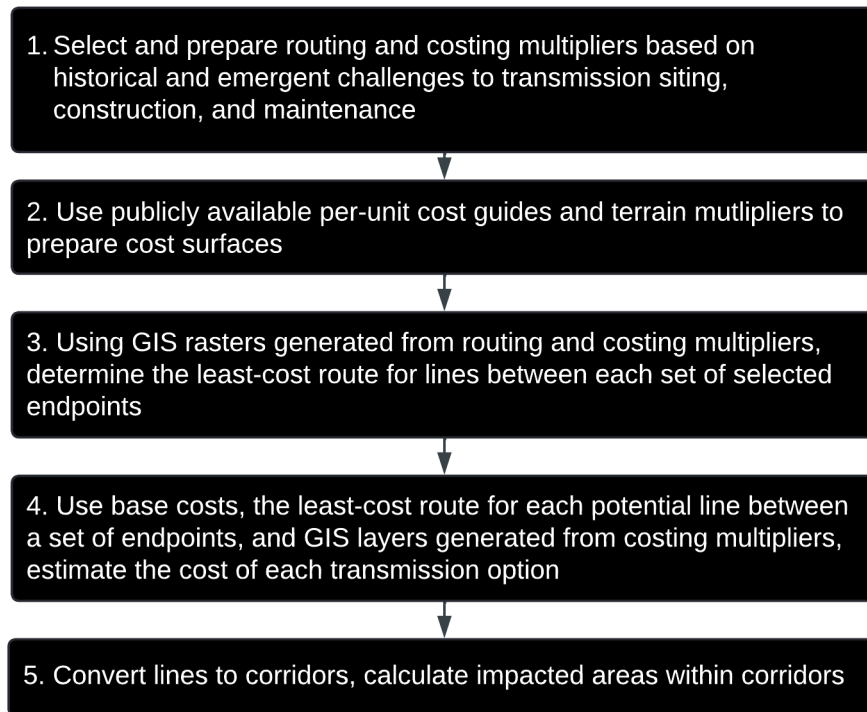


Figure 14. optimal cost path transmission route identification work flow

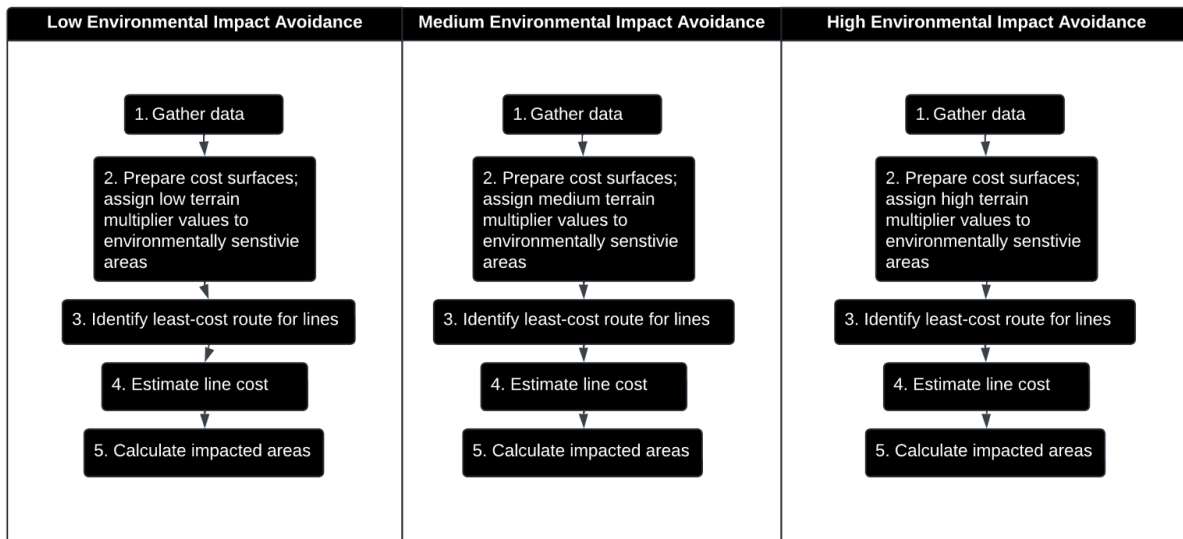


Figure 15. environmental impact avoidance sensitivity analysis work flow

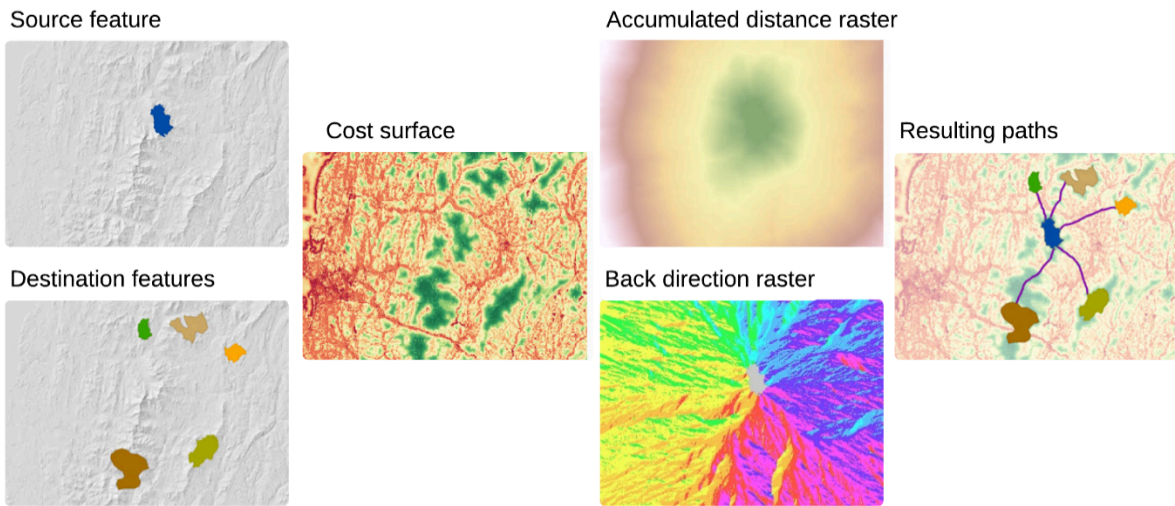


Figure 16. Flow chart summarizing Dijkstra's algorithm based on ESRI Introduction to Optimal Path Analysis

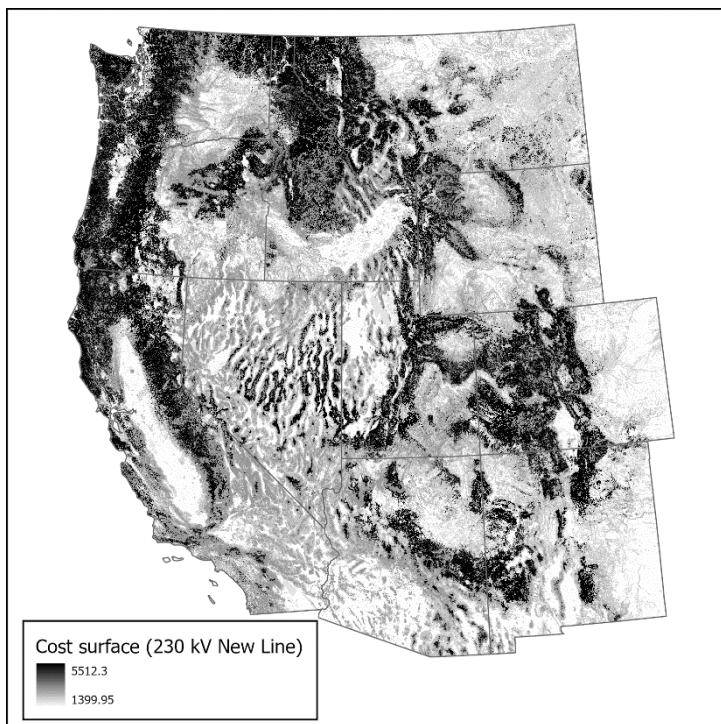


Figure 17. Example cost surface, \$/m

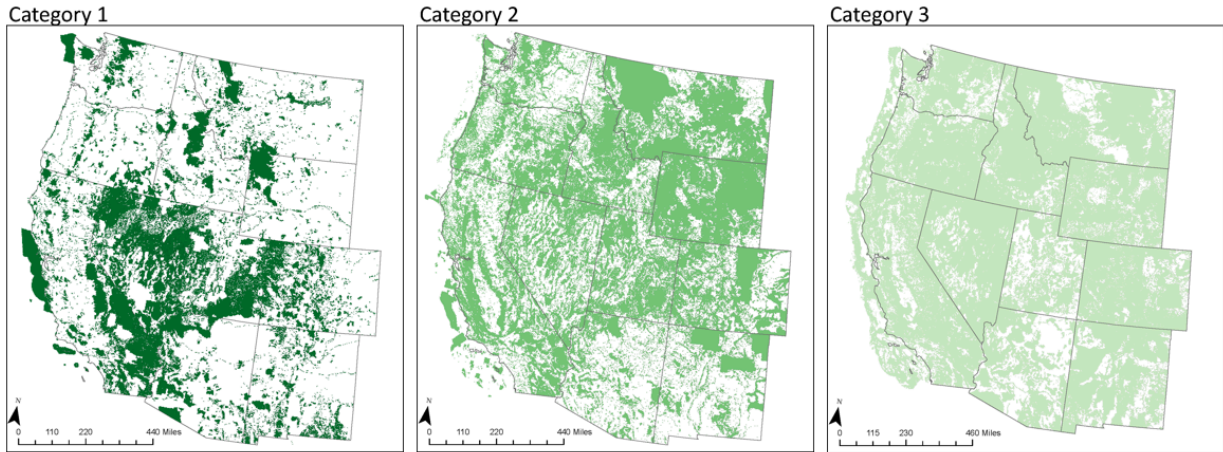


Figure 18. Levels of environmental sensitivity per Wu et al

Multiplier type	Source	Criteria	Value	Construction Cost?
Slope	USGS	Slope: Mountain	1.75	yes
Slope	USGS	Slope: Rolling hills	1.4	yes
Slope	USGS	Slope: Flat	1	yes
Terrain	MRLCD	Forested	2.25	yes
Terrain	MRLCD	Urban	1.59	yes
Terrain	MRLCD	Water	1.3	yes
Terrain	MRLCD	Scrubbed/farmland	1.1	yes
Environmental Risk	The Nature Conservancy	Environmental 1: development prohibited	[1.75, 1.9]	no
Environmental Risk	The Nature Conservancy	Environmental 2: administrative review	[1.2, 1.6]	no
Environmental Risk	The Nature Conservancy	Environmental 3: conservation value	[1.1, 1.3]	no
Environmental Risk	The Nature Conservancy	Environmental: No category	1	no
Airports and runways	ANL EZMT	includes sites and runways	1.5	yes
Wildfire risk	Risk to Potential Structures, USDA Forest Service	top quartile	1.2	no
Tribal lands	USGS	PAD-US	[1.75, 1.9]	no
Existing ROW	HIFLD	200 ft corridor width	9x where avoided	no

Figure 19. Input terrain datasets and multiplier values assigned

Table 6. Transmission per-unit cost values based on MISO Per Unit Cost Guide. Note a 10-25% cost adder was applied to account for assumption of advanced conductors, based on the 2024 Gridlab/Berkeley/Haas Energy Institute advanced conductor report.

AC Voltage (kV)	Avg. \$M/mile
115	1.9
230	2.3
345	3.6
500	4.5
HVDC Voltage (kV)	Avg. \$M/mile

500	2.9
<b>AC Voltage Reconductor (kV)</b>	<b>Avg. \$M/mile</b>
115	0.39
230	0.39
345	0.62
500	0.83

Table 7. Input assumptions underlying per-unit cost values. Source: [MISO Transmission Per Unit Cost Guide](#), Tables 4.1-1, 4.1-3, 4.1-4

<b>500 kV AC transmission</b>	<b>500 kV HVDC transmission</b>
steel pole/tower, single circuit	steel pole/tower, single circuit
Structures per mile:	Structures per mile:
Tangent structure: 3.0	Tangent structure: 3.5
Running angle structures: 1	Running angle structures: 0.5
Non-angled dead-end structures: 0.25	Non-angled dead-end structures: 0.25
Angled dead-end structures: 0.25	Angled dead-end structures: 0.25
Conductor size: 954 kcmil	Conductor size: 1,590 kcmil
Conductor Type: ACSS	Conductor Type: ACSR
Conductor quantity: 3	Conductor quantity per pole: 2
Amp rating: 3,000	Power transfer: 2,000 MW
Power Rating MVA: 2,598	

## Appendix B: Environmental sensitivity data

To design the environmental impact avoidance scenarios, we incorporated data from The Nature Conservancy Power of Place study<sup>3</sup> and the WSU Least Conflict Solar Siting Study.<sup>4</sup> Data are grouped into categories corresponding to levels of environmental sensitivity (Category 1, Category 2, Category 3, corresponding to high, medium, and low levels of environmental sensitivity). These environmental sensitivity levels correspond to WECC Environmental Risk Categories 4, 3, and 2.

For more information and a complete inventory of Power of Place environmental data, see the 2023 PNAS article<sup>5</sup> Supporting Information,<sup>6</sup> Tables S17-S19.

For an inventory of the WSU Solar Siting Study environmental data, see tables below. We downloaded the WSU composite data layer and filtered to identify areas classified as high-conflict, medium-conflict, and low-conflict for each data type (conservation, farmland, rangeland). High-conflict areas were treated as Category 1, medium-conflict areas were treated as Category 2, and low-conflict areas were treated as Category 3. The composite data layer incorporates information for each data type: solar site suitability, conservation, farmland, rangeland. See inventory of datasets aggregated for each data type in tables 7-10 below.

We also incorporated the WAHCAP cores and corridors and treated them as high-conflict for environmental avoidance.

Table 8. WSU Solar Siting Study: Solar Site Suitability

Solar Site Suitability Factors considered in 2023 WSU study
<a href="#">National Land Cover (NLCD) 2019 for the Washington Columbia Plateau</a>
<a href="#">Wetland PHS Input</a>
<a href="#">Aspect-Slope, Columbia Plateau WA</a>

<sup>3</sup>

<https://www.nature.org/en-us/what-we-do/our-priorities/tackle-climate-change/climate-change-stories/power-of-place/>

<sup>4</sup> <https://www.energy.wsu.edu/RenewableEnergy/LeastConflictSolarSiting.aspx>

<sup>5</sup> Wu, G.; Jones, R.; Leslie, E.; Williams, J.; Pascale, A.; Brand, E.; Parker, S.; Cohen, B.; Fargione, J.; Souder, J.; Batres, M.; Gleason, M.; Schindel, M.; Stanley, C. Minimizing Habitat Conflicts in Meeting Net-Zero Energy Targets in the Western United States. *Proceedings of the National Academy of Sciences* **2023**, *120* (4). <https://doi.org/10.1073/pnas.2204098120>.

<sup>6</sup> [https://www.pnas.org/doi/suppl/10.1073/pnas.2204098120/suppl\\_file/pnas.2204098120.sapp.pdf](https://www.pnas.org/doi/suppl/10.1073/pnas.2204098120/suppl_file/pnas.2204098120.sapp.pdf)

<a href="#">Electric Power Transmission Lines, Washington</a>
<a href="#">Electric Substations, Washington</a>
<a href="#">Soil Survey Geographic (SSURGO) - Percent Clay for Washington, USA</a>
<a href="#">gNATSGO - Percent Rock, WCP</a>
<a href="#">WSDOT - State Route Line (1:24K) 2020</a>
<a href="#">WSDOT National Highway System for Non State Routes</a>
<a href="#">WSDOT Functional Class Data for Non State Routes</a>
<a href="#">Interagency Fire Perimeter History - Current Decade</a>
<a href="#">BLM OR Wildfire Perimeter History Polygon</a>
<a href="#">Seismogenic Features (Faults and Earthquakes), Washington</a>
<a href="#">Washington State Hydrography - NHDWaterbody</a>
<a href="#">Protected Areas Database of the United States (PAD-US) 3.0 Washington</a>
<a href="#">Hanford CLUP EIS Land Use Designations</a>

Table 9. WSU Solar Siting Study: Conservation

<b>Conservation Factors considered in 2023 WSU study</b>
<a href="#">California Mountain Kingsnake Habitat, Washington Columbia Plateau</a>
<a href="#">Northern Leopard Frog Priority Habitat, Washington Columbia Plateau</a>
<a href="#">Sandhill Crane Observations, Washington Columbia Plateau</a>
<a href="#">Conservation CRP Input</a>
<a href="#">Western Gray Squirrel Habitat, Washington Columbia Plateau</a>
<a href="#">Listed Species Composite, Washington Columbia Plateau</a>
<a href="#">Western Pond Turtle Habitat Areas, Washington Columbia Plateau</a>
<a href="#">National Land Cover (NLCD) 2019 for the Washington Columbia Plateau</a>
<a href="#">Protected Areas Database of the United States (PAD-US) 3.0 Washington</a>
<a href="#">WDFW Ecosystems of Concern</a>
<a href="#">Oak Habitat Priority Analysis - East Cascades Oak Partnership</a>
<a href="#">Biome-wide Sagebrush Core Habitat and Growth Areas, 2020</a>
<a href="#">United States Important Bird Areas - National Audubon Society ...</a>
<a href="#">TNC Northwest Plan Portfolios</a>

<a href="#">Priority Habitats and Species: Shrubsteppe General Locations, ...</a>
<a href="#">Arid Lands Initiative (ALI) Cores and Linkages, Washington Columbia ...</a>
<a href="#">WDFW Cores and Linkages, Washington Columbia Plateau</a>
<a href="#">Riparian Areas, Washington Columbia Plateau</a>
<a href="#">Waterfowl Concentration Inputs</a>
<a href="#">Rare Wetland and Riparian Communities (NHP), Washington Columbia Plateau</a>
<a href="#">Rare Upland Or High Quality Upland Communities (NHP), Washington ...</a>
<a href="#">Inland Dunes, Washington Columbia Plateau</a>
<a href="#">Aspen Stands, Washington Columbia Plateau</a>
<a href="#">Sensitive Vascular and Non-Vascular Plants (NHP), Washington Columbia ...</a>
<a href="#">Threatened Vascular and Non-Vascular Plants (NHP), Washington Columbia ...</a>
<a href="#">Cliffs and Bluffs, Washington Columbia Plateau</a>
<a href="#">Talus Slopes, Washington Columbia Plateau</a>
<a href="#">Endangered Vascular and Non-Vascular Plants (NHP), Washington Columbia ...</a>
<a href="#">Irrigated Crops, Washington Columbia Plateau</a>
<a href="#">Dryland Crops, Washington Columbia Plateau</a>
<a href="#">Wetland PHS Input</a>
<a href="#">Striped Whipsnake Priority Habitat, Washington Columbia Plateau</a>
<a href="#">Sagebrush Lizard Habitat, Washington Columbia Plateau</a>
<a href="#">Priority Amphibian and Reptile Conservation Areas (PARCA), Washington</a>
<a href="#">Sharptailed Snake General Occurrences, Washington Columbia Plateau</a>
<a href="#">Columbia Spotted Frog General Occurrences, Washington Columbia Plateau</a>
<a href="#">Modeled Greater Sage Grouse Habitat, Washington Columbia Plateau</a>
<a href="#">Golden Eagle Generalized Occurrences, Washington Columbia Plateau</a>
<a href="#">Burrowing Owl Generalized Occurrences, Washington Columbia Plateau</a>
<a href="#">Brewers Sparrow Modeled Suitability, Washington Columbia Plateau</a>
<a href="#">Modeled Sagebrush Sparrow Habitat Suitability, Washington Columbia ...</a>
<a href="#">Columbian Sharp-tailed Grouse Habitat Concentration Areas, Washington ...</a>
<a href="#">Loggerhead Shrike Priority Habitat, Washington Columbia Plateau</a>
<a href="#">Modeled Sage Thrasher Habitat Suitability, Washington Columbia Plateau</a>

<a href="#">Ferruginous Hawk Generalized Occurrences, Washington Columbia Plateau</a>
<a href="#">Bighorn Sheep Priority Habitat, Washington Columbia Plateau</a>
<a href="#">Rocky Mountain Elk Priority Habitat, Washington Columbia Plateau</a>
<a href="#">Elk Parturition Priority Habitat, Washington Columbia Plateau</a>
<a href="#">Elk Priority Habitat, Washington Columbia Plateau</a>
<a href="#">Elk Migration Priority Habitat, Washington Columbia Plateau</a>
<a href="#">White-tailed Jackrabbit Habitat Concentration Areas, Washington ...</a>
<a href="#">Pygmy Rabbit Habitat Suitability, Washington Columbia Plateau</a>
<a href="#">General Cave Areas Important for Bat Species, Washington Columbia ...</a>
<a href="#">Black-tailed Jackrabbit Habitat Concentration Areas, Washington ...</a>
<a href="#">Townsend's Ground Squirrel Habitat Concentration Areas, Washington ...</a>
<a href="#">Washington Ground Squirrel Habitat Concentration Areas, Washington ...</a>
<a href="#">Mule Deer Priority Habitat, Washington Columbia Plateau</a>

Table 10. WSU Solar Siting Study: Farmland

<b>Farmland Factors considered in 2023 WSU study</b>
<a href="#">Conservation Reserve Program Lands (2022), Washington Columbia Plateau</a>
<a href="#">Washington State Hydrography - NHDWaterbody</a>
<a href="#">Conservation Reserve Program Lands (2022), Washington</a>
<a href="#">Irrigation Districts and Buffered Canals and Ditches, Washington ...</a>
<a href="#">City Limits, Washington Columbia Plateau</a>
<a href="#">Dryland Crops, Washington Columbia Plateau</a>
<a href="#">Irrigated Crops, Washington Columbia Plateau</a>
<a href="#">Perennial Water - NHD, Washington Columbia Plateau</a>
<a href="#">Protected Areas, Washington Columbia Plateau</a>
<a href="#">Annual Precipitation 1991-2020 (PRISM), Washington Columbia Plateau</a>
<a href="#">gNATSGO - Irrigated Capability Class, Washington Columbia Plateau</a>
<a href="#">gNATSGO - Available Water Storage, Washington Columbia Plateau</a>
<a href="#">gSSURGO - National Commodity Crop Productivity Index, Washington ...</a>
<a href="#">Soil Organic Carbon, Washington Columbia Plateau</a>
<a href="#">gSSURGO - Depth to Soil Restrictive Layer, Washington Columbia Plateau</a>
<a href="#">Irrigation Districts, Washington Columbia Plateau</a>

Groundwater Wells GWIS, Washington Columbia Plateau

Table 11. WSU Solar Siting Study: Ranchland

<b>Ranchland Factors considered in 2023 WSU study</b>
<u>Conservation Reserve Program Lands (2022), Washington Columbia Plateau</u>
<u>Washington State Agricultural Land Use - 2022</u>
<u>Conservation Reserve Program Lands (2022), Washington</u>
<u>Grazing Allotments with Animal Management Units, Oregon and Washington</u>
<u>Annual Invasives RAP, Washington Columbia Plateau</u>
<u>Bare Ground RAP, Washington Columbia Plateau</u>
<u>Perennial Grass and Forbs RAP, Washington Columbia Plateau</u>
<u>gSSURGO - Depth to Soil Restrictive Layer, Washington Columbia Plateau</u>
<u>gNATSGO - Available Water Storage, Washington Columbia Plateau</u>
<u>Irrigated Crops, Washington Columbia Plateau</u>
<u>Seeps and Springs NHD, Washington Columbia Plateau</u>
<u>Groundwater Wells GWIS, Washington Columbia Plateau</u>
<u>Annual Precipitation 1991-2020 (PRISM), Washington Columbia Plateau</u>
<u>City Limits, Washington Columbia Plateau</u>
<u>Perennial Water - NHD, Washington Columbia Plateau</u>
<u>Protected Areas, Washington Columbia Plateau</u>

## Appendix C: Line Descriptions

This Appendix contains detailed descriptions and illustrations of each line segment in the high deployment scenario. These routes were developed algorithmically. There may be improvements that could be made with input from local communities.

### Low Deployment Scenario

#### *Townsend to Midpoint*

The low deployment scenario consists of the Townsend to Midpoint project, treated as a 500 kV new greenfield line only. This project runs from Midpoint in southern Idaho to Townsend in central Montana. It is a new 500 kV line. It follows a predetermined route, and there was no customization or detailed optimization of the shape of this route. It is co-located with existing transmission lines for the entirety of its length. We did not calculate the teardown cost of the existing line. It runs east from the Midpoint substation alongside the Snake River (within 2 to 15 miles) for a 75-mi segment in Southern Idaho, threading between Craters of the Moon National Preserve and Minidoka National Wildlife Refuge. It weaves north through valleys adjacent (south and east) of the Beaverhead and Pioneer mountains, generally avoiding the steeper parts of both ranges. It veers east at the confluence of Little Blackfoot and Clark Fork rivers, crossing the Boulder mountains and the Missouri River and Highway 287 to reach an eastern terminus at the Townsend substation between Helena and Livingston Montana.

Overall, the line is about 475 mi long, with about 60% in Montana and 40% in Idaho.

It passes through the following counties: Bingham County, ID, Blaine County, ID, Butte County, ID, Clark County, ID, Jefferson County, ID, Jerome County, ID, Lincoln County, ID, Minidoka County, ID, Power County, ID, Beaverhead County, MT Broadwater County, MT, Deer Lodge County, MT, Jefferson County, MT, Powell County, MT, Silver Bow County, MT.

The corridor has 7,000 acres of Category 2 environmental sensitivity land (protected and administrative review but not prohibited), and 10,000 acres of Category 3 land (known conservation value, but not legally protected).

There is no new land acquisition cost for the Right-Of-Way (ROW), since the entire project follows existing ROW. Even so, it is still worth noting that the corridor segments with the top-quartile land values occur in Minidoka, Power, Bingham counties in Idaho, and Silver Lodge, Deer Bow, Powell and Broadwater counties in Montana.

It has 3600 acres of high-wildfire-risk land, mostly in Jerome, Blaine, Butte Counties in Idaho, and Powell and Jefferson Counties in Montana.

It has 2800 acres of mountainous terrain, mostly in Clarke County Idaho and Powell and Jefferson Counties in Montana. It does not cross any federally recognized tribal reservation land, nor does it have any segment within 5 mi of tribal land.

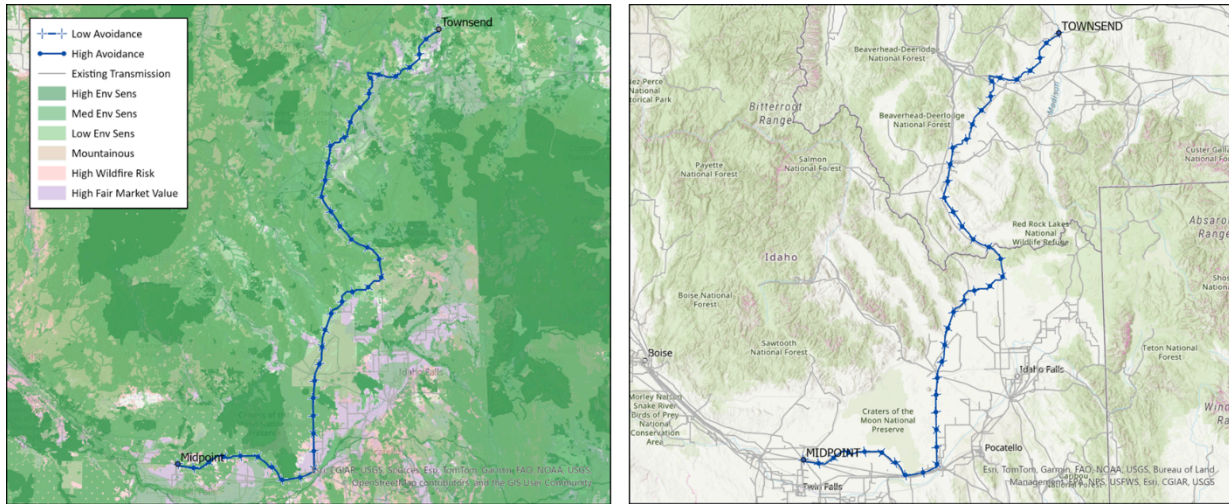


Figure 21. Townsend to Midpoint

**Townsend to Midpoint: Candidate Project Area**

Table 17. Wind Candidate Project Area within 15 mi of Townsend to Midpoint line, low and high avoidance scenarios

Transmission Route	Wind CPA (GW)
Low Avoidance	43
High Avoidance	6

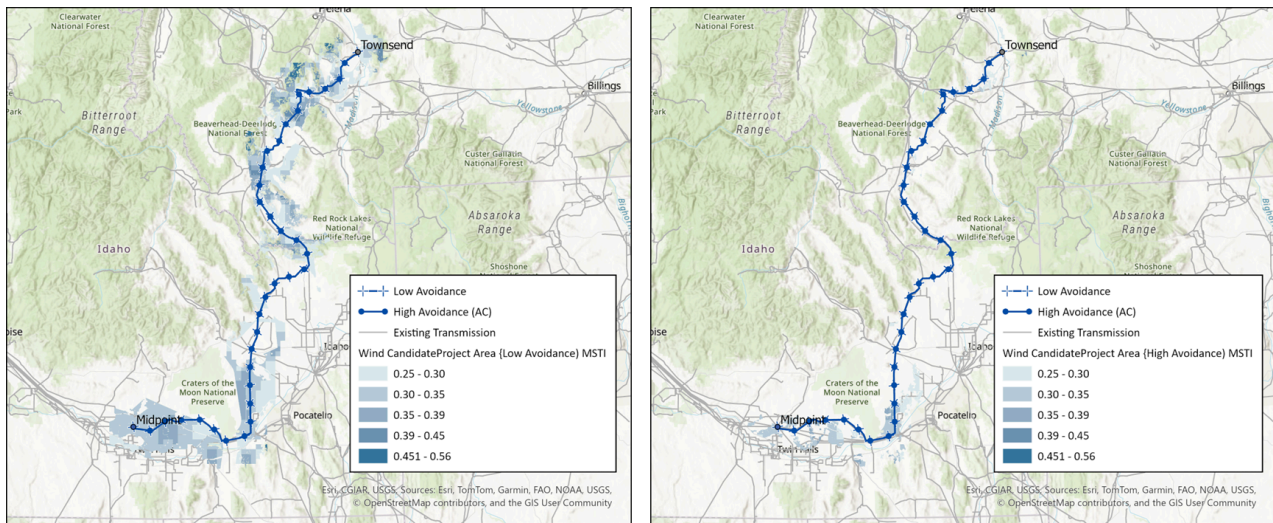


Figure 21. Wind Candidate Project Area within 15 mi of Townsend to Midpoint line, low and high avoidance scenarios

## Medium Deployment Scenario

The medium deployment scenario consists of 12 lines, summarized by type and length in the table below

From Name	To Name	Upgrade Type	Voltage	Shape Length (mi)	Line cost terrain only (\$m/mi)	Percent of base cost
BELL_BPA	ASHE	New Line	500	136	4.8	118%
GARRISON	LIT_GOS	New Line	500	294	6.0	146%
TAFT	BELL_BPA	New Line	500	97	6.2	151%
GTF 500	BROADVIEW	New Line	500	162	5.1	123%
TOWNSEND	MIDPOINT	New Line	500	432	5.7	139%
GTF 500	TAFT	New Line	500	263	9.3	226%
THOMPSONFALLS	BURKE	Reconductor	115	32	0.3	83%
GTF 230SWYD	BROADVIEW	Reconductor	230	169	0.5	131%
OVANDO	PLACID LAKE	Reconductor	230	30	0.6	152%
GARRISON	TAFT	Reconductor	500	182	1.1	136%
TAFT	BELL_BPA	Reconductor	500	102	0.6	78%
TAFT	DWORSHAK	Reconductor	500	94	1.0	125%

### *Bell to Ashe*

The 500 kV line is 138 mi long, running from Spokane to Kennewick. The line cost is 118% of the base cost for this line type. It does not cross any major mountains, crosses 2 rivers (Spokane and Columbia), and 5 major roads (I-90, US Hwy 2, State Rte 17, US Hwy 395). It is a new greenfield line with little proximity to existing transmission corridors.

It crosses the following environmentally sensitive areas: 1% highly sensitive, 3% moderately sensitive and administratively protected, and 23% known conservation value. There are 2 acres federally recognized tribal lands within the corridor, and 1,330 acres of tribal land within 5 miles. It crosses primarily Adams county (42%), Lincoln County (20%), and Spokane County (19%), all in Washington state. The corridor is located 4% on federal (DoD) land. Along the route, 27% of the line occurs in locations with highest fair market real estate land value. The locations with highest fair market real estate land value are around the northern terminus in the Spokane area, and the southern terminus in Franklin county. There is a small (10 mi) segment with high wildfire risk in Adams county. There are no segments with the highest slope (>45 deg).

It is one of the bottom few lower-cost line options, at 118% of base costs on a per-mile basis.

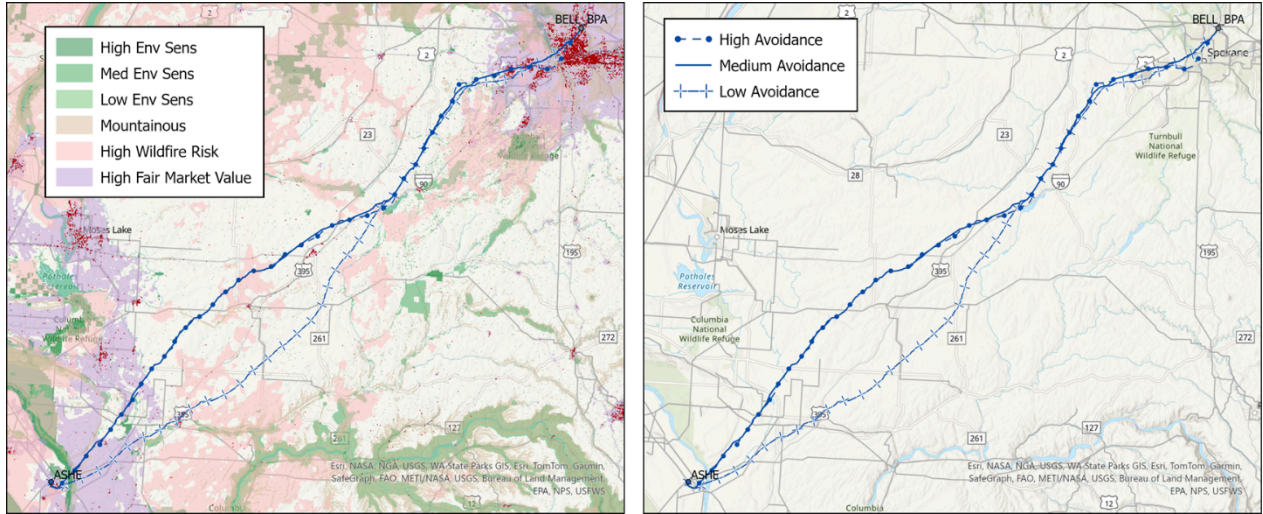


Figure 21. Bell to Ashe overlaid with terrain features (left) and simple topo map (right)

### Bell to Ashe: Wind Candidate Project Areas

Table 17. Wind Candidate Project Area within 15 mi of Bell to Ashe lines, low and high avoidance scenarios

Transmission Route	Wind CPA (GW)
Low Avoidance	11
High Avoidance	6

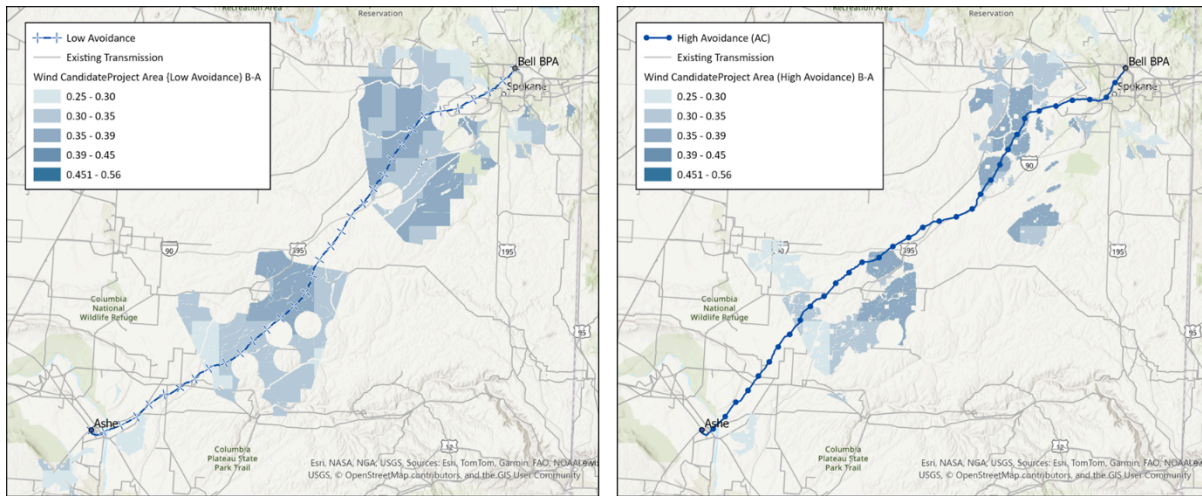


Figure 22. Wind Candidate Project Area within 15 mi of Bell to Ashe lines, low (left) and high avoidance (right) scenarios

### Garrison to Little Goose

The Garrison to LIT\_GOS 500 kV AC new line is 294 mi long, running from south of Ovando Montana through Missoula to a rural area northeast of Kennewick and Walla Walla Washington.

The line cost is 146% of the base cost for this line type. It skirts north of the Sapphire range, and crosses the Clearwater mountains, crosses 4 rivers (North fork Clearwater, Potlatch, Clark Fork, and Blackfoot), and 5 major roads (I-90, Hwy 12, Hwy 195, Hwy 93, Hwy 95). It follows existing transmission line corridors for 43% of its length, primarily the Garrison to Rattlesnake segment (230 kV; BPA). The western half of the line is a new greenfield line relatively remote from existing transmission corridors.

It crosses the following environmentally sensitive areas: 1.5% highly sensitive (small protected areas scattered outside Missoula), 47% moderately sensitive and administratively protected (majority of the eastern half of the line, plus a small crossing into the Snake River scenic watershed surrounding the Lit Gos substation at the western end), and 70% known conservation value (most the eastern part of the line, except for the westernmost 40 miles). There are no federally recognized tribal lands within the corridor, and 125 acres of tribal land within 5 miles. It crosses 7 counties (Clearwater, Granite, Latah, Mineral, Missoula, Powell, Whitman), and 19% of the line occurs on federal (forest service) land. Along the route, the locations with highest fair market real estate land value are in Mineral, Latah, Whitman, Granite, Missoula, and Powell counties. The segments with the highest wildfire risk are in Missoula, Mineral, Latah, Clearwater, Granite, Powell counties. The segments with the highest slope (>45 degrees) are in Mineral county Montana and Clearwater County Idaho. These areas are in the top 1% steepest slope areas in the continental U.S.

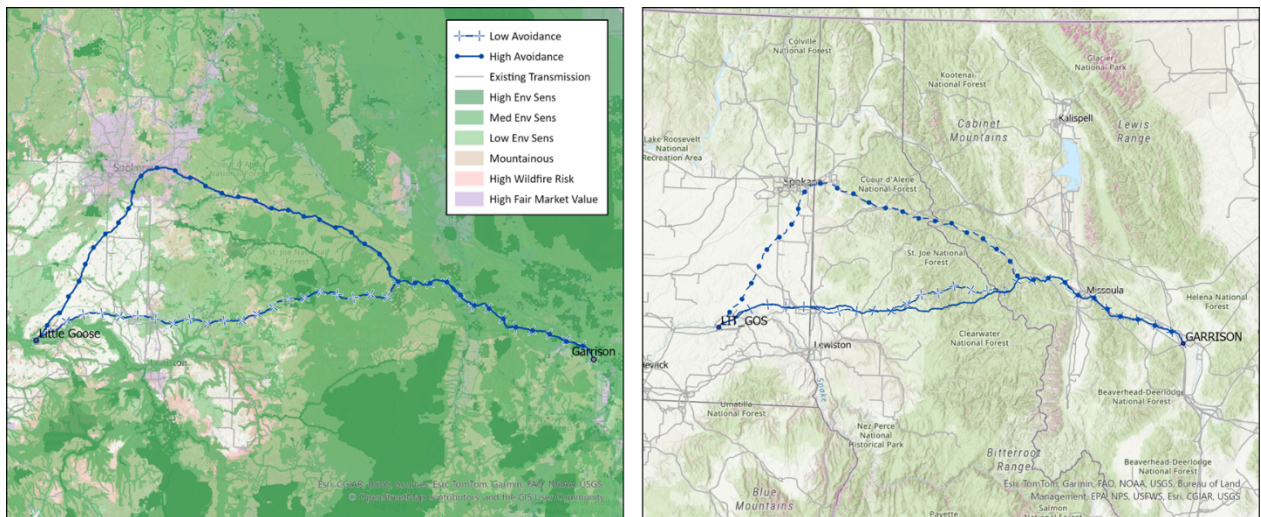


Figure 22. Garrison to Little Goose

In the most restrictive scenario, the Garrison to Little Goose line shifts significantly northward, and much of the wind candidate project area in the eastern part of the Garrison to Little Goose line (around Garrison) is eliminated, leaving the majority of the remaining wind resource on the western side (around Little Goose).

## Garrison to Little Goose: Wind Candidate Project Areas

Table 17. Wind Candidate Project Area within 15 mi of Garrison to Little Goose lines, low and high avoidance scenarios

Scenario	Wind CPA (GW)
Low Avoidance	16
High Avoidance	5

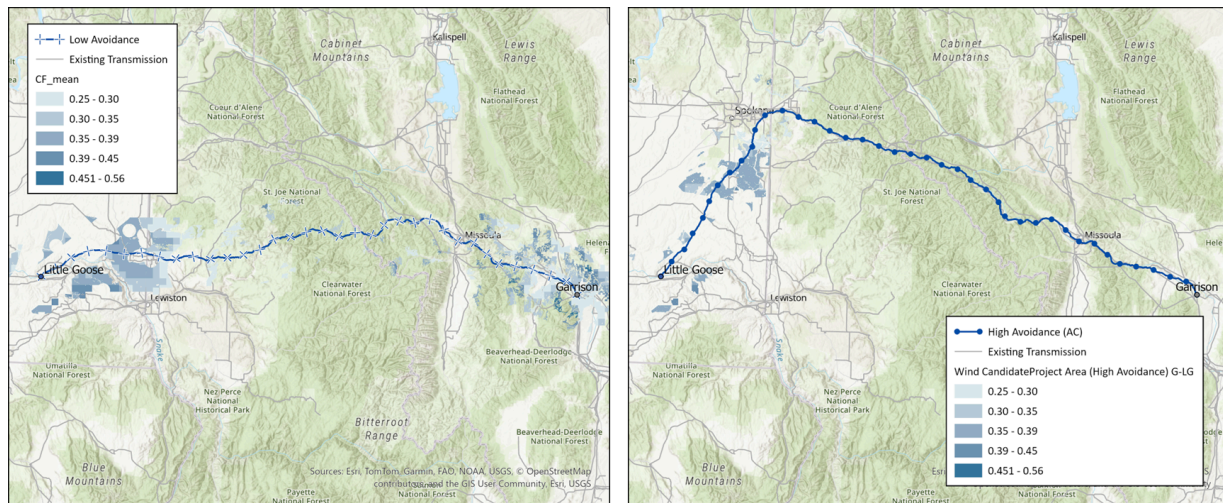


Figure 23. Wind Candidate Project Area within 15 mi of Garrison to Little Goose lines, low and high avoidance scenarios

## Taft to Bell (BPA)

The Taft to Bell line is a 97 mi long 500 kV AC new line, running from the Taft substation in the Taft mountains northwest of Missoula to the Bell substation north of Spokane. The line cost is 151% of the base cost for 500 kV lines. It crosses the Couer D'Lane mountains, crosses the Coeur d'Alene River, and 2 major roads (I-90 and Hwy 95). It follows I-90 closely for the majority of its length. It follows existing transmission line corridors for 88% of its length, primarily 69 kV segments (Avista) and a 115 kV segment owned by BPA near the Bell substation.

The corridor has the following environmentally sensitive areas: 0% highly sensitive, 9% moderately sensitive and administratively protected, and 21% known conservation value. There are no federally recognized tribal lands within the corridor, and no federally recognized tribal lands within 5 miles. It crosses Kootenai and Shoshone counties in Idaho, and Spokane county in Washington. It has 4% of the line occurring on US BLM land, while 70% occurs on USFS land. This entire route tends to follow a corridor of high fair market real estate land value in all 3 counties. All of the area within about 25 mi of the Bell substation has high fair market value (top quartile). The eastern half of the line tends to follow a valley along I-90 (Kellog, Osborne, Mullah) and the land in this valley also has high fair market value (top quartile). This line does not have any segments in the top quartile high wildfire risk. The segments with the highest slope (>45 deg) are in Shoshone County Idaho.

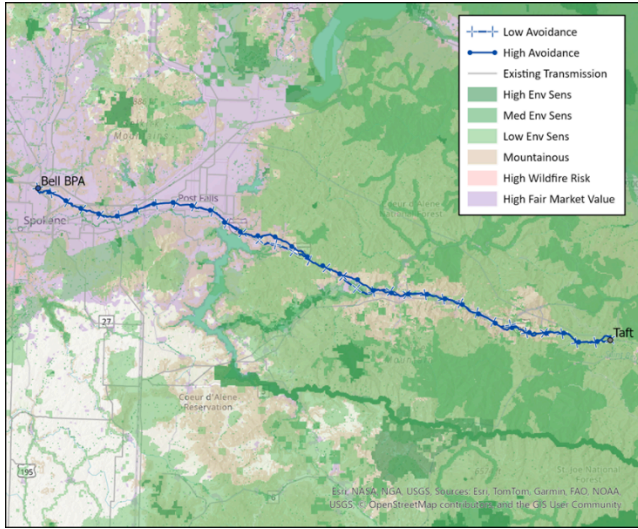


Figure 23. Taft to Bell new line

Taft To Bell: Wind Candidate Project Area

Table 20. Wind Candidate Project Area within 15 mi of Taft to Bell new line, low and high avoidance scenarios

Scenario	Wind CPA (GW)
Low Avoidance	3
High Avoidance	1

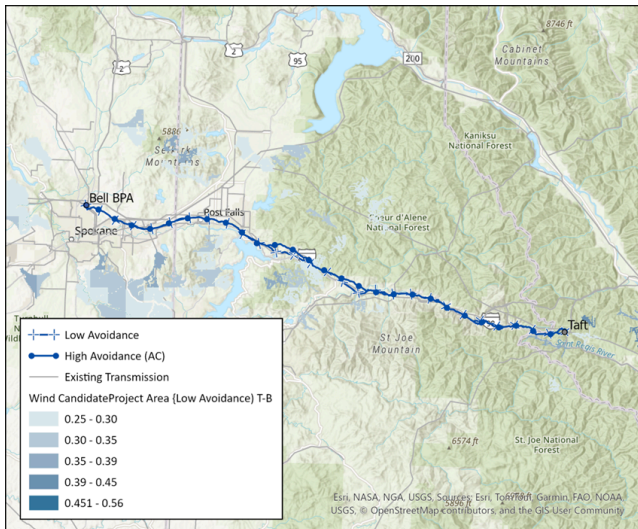


Figure 27. Wind Candidate Project Area within 15 mi of Taft to Bell new line, low and high avoidance scenarios

### Great Falls (500 kV) to Broadview

The Great Falls to Broadview line is 162 mi long, running from Great Falls, to the east of the Little Belt Mountains, to the Broadview substation just north of Billings. The line cost is 123% of the base cost for this line type. It largely avoids mountainous terrain, crosses 7 rivers (Missouri River, Fish Creek, Judith River, Belt Creek, Surprise Creek, Sage Creek, Musselshell River), and major roads (US Hwy 12, US Hwy 191, US Hwy 87). It follows existing transmission line corridors for 51% of its length, (Broadview to Judith Gap 230 kV; other 69 and 115 kV segments owned by Northwestern).

It crosses the following environmentally sensitive areas: 0% highly sensitive , 21% moderately sensitive and administratively protected , and 29% known conservation value . There are no federally recognized tribal lands within the corridor or within 5 miles. It crosses 7 counties (Cascade, Fergus, Golden Valley, Judith Basin, Stillwater, Wheatland, Yellowstone), and 2% of the line occurs on federal (DoD) land. Along the route, the locations with highest fair market real estate land value are in Cascade and Wheatland counties. There are no segments with high wildfire risk. The segments with the highest slope occur at the Belt Creek river crossing in Cascade county.

It is one of the bottom few lower-cost lines at 123% of base cost on a per-mile basis.

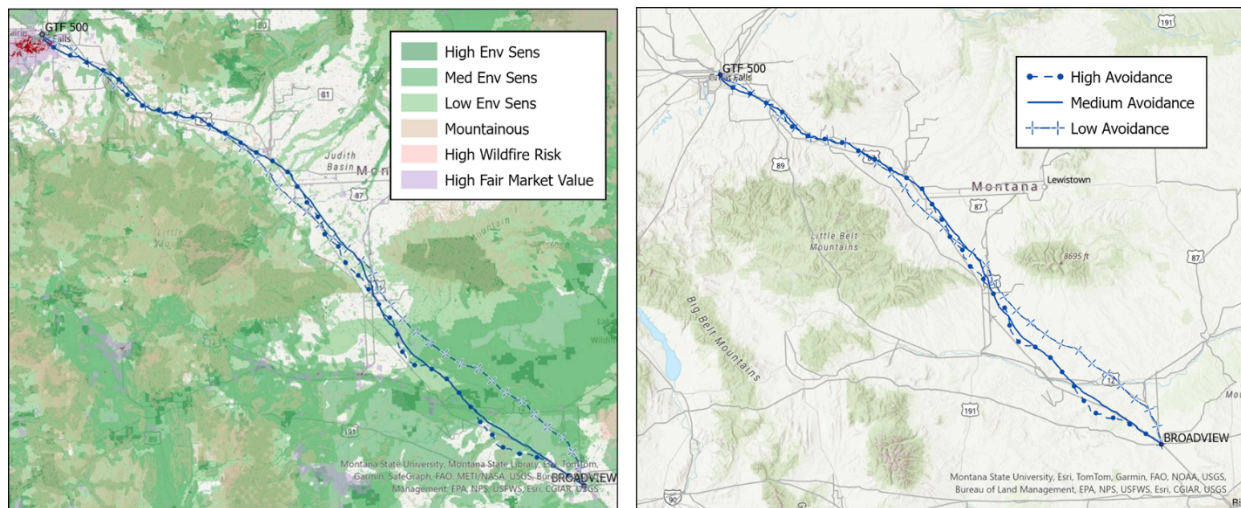


Figure 24. Great Falls to Broadview, overlaid with terrain features (left) and simple topo map (right)

### Great Falls to Broadview: Wind Candidate Project Area

Table 20. Wind Candidate Project Area within 15 mi of Great Falls to Broadview new line, low and high avoidance scenarios

Scenario	Wind CPA (GW)
Low Avoidance	34
High Avoidance	12

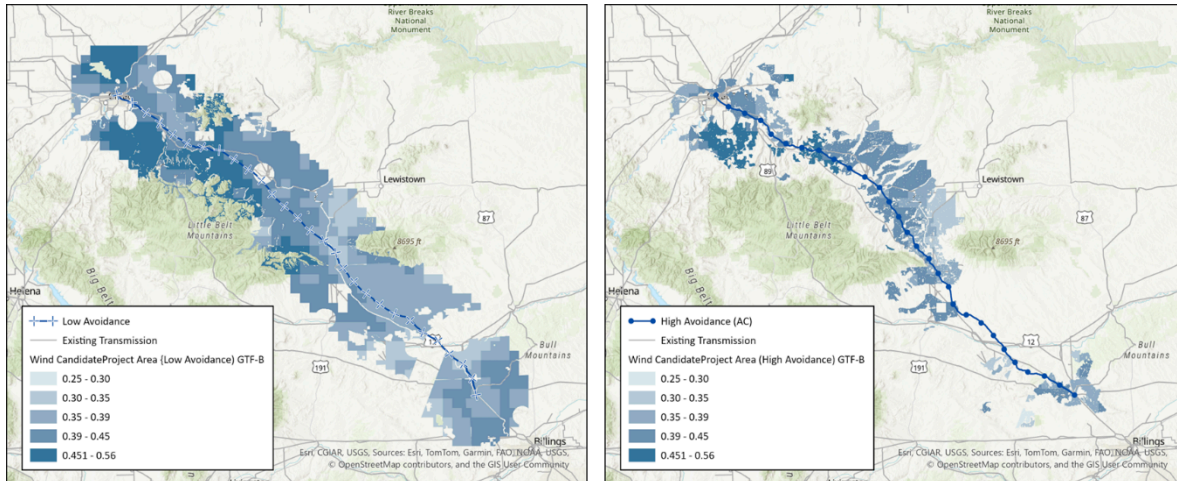


Figure 29. Wind Candidate Project Area within 15 mi of Great Falls to Broadview new line, low and high avoidance scenarios

### *Townsend to Midpoint*

The TOWNSEND to MIDPOINT line is a 500 kV new line, 432 mi long, running from Townsend near the city of Helena, to Midpoint near the city of Twin Falls Idaho. The line cost is 127% of the base cost for this line type. The terrain is the same as previously described in the low-deployment scenario.

### *Great Falls to Taft*

The Great Falls to Taft line is a new 500 kV ac line, 263 mi long, running from Great Falls South of the Lewis and Clark Wilderness through Ovando, west to the Taft substation between Flathead Lake and Spokane. The line cost is 226% of the base cost for this line type. It crosses the Couer D'Alene, Koo Koo Sint, and Mission mountain ranges, crosses Clark Fork, Clearwater, Flathead, Little Bitterroot, Blackfoot, Thompson, Dearborn, and Sun rivers, and 5 major roads (US Hwy 287, US Hwy 87, US Hwy 93, I-15, US Hwy 89). It follows existing transmission line corridors for 100% of its length, primarily the following segments: Landers Fork to Great Falls 230 kV owned by Northwestern, Landers Fork to Ovando, Ovando to Placid Lake, Placid Lake to Hot Springs, Thompson Falls to Kerr 69 kV, Taft to Hot Springs 500 kV owned by BPA, and a 69 kV parallel line owned by Northwestern.

It crosses the following environmentally sensitive areas: 11% highly sensitive , 85% moderately sensitive and administratively protected , and 74% known conservation value . The corridor traverses the Flathead Indian Reservation (6300 acres), and 7800 acres of tribal land within 5 miles. It crosses 7 counties (Cascade, Lake, Lewis and Clark, Mineral, Missoula, Powell, Sanders), and 9% of the line occurs on federal (USFS) land. Along the route, the locations with highest fair market real estate land value are in Sanders and Powell counties. The segments with the highest

wildfire risk are in Missoula, Powell, and Lewis and Clark counties. The segments with the highest slope (>45 deg) are in Sanders, Lake, and Missoula counties.

This is one of the top few higher-cost lines, at 226% of base cost, on a per-mile basis.

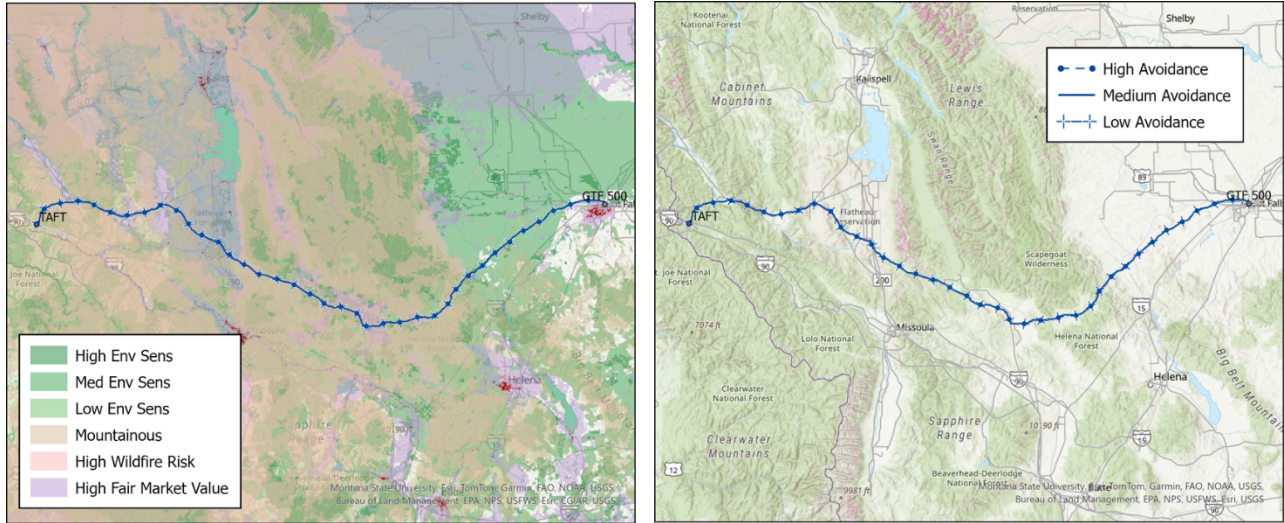


Figure 25. Great Falls to Taft, overlaid with terrain features (left), and simple topographic map (right)

### Great Falls to Taft: Wind Candidate Project Areas

Table 20. Wind Candidate Project Area within 15 mi of Great Falls to Taft, low and high avoidance scenarios

Scenario	Wind CPA (GW)
Low Avoidance	19
High Avoidance	3

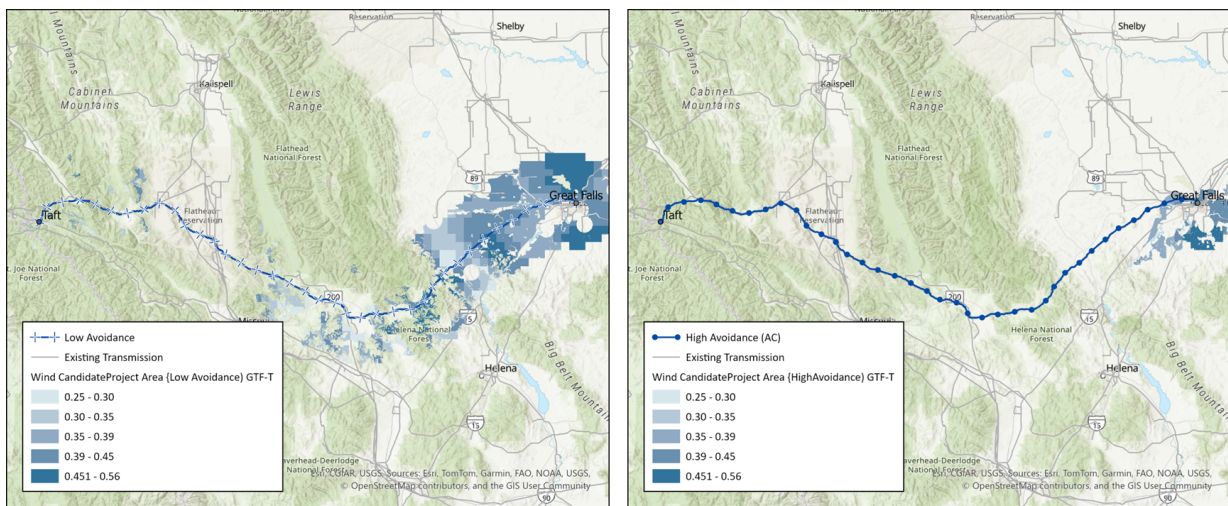


Figure 29. Wind Candidate Project Areae within 15 mi of Great Falls to Taft, low and high avoidance scenarios

### Thomson Falls to Burke

The THOMPSONFALLS to BURKE line is a 115 kV reconductor line, 32 mi long, running from the Thomson Falls substation south and west to cross the Clark Fork River and follow Prospect creek road through the Couer Dalene mountains, south to the Taft substation, then veering west to follow the south fork of the Couer D’Alene river across Gentle Annie gulch to terminate at Burk on Canyon creek north of Grouse peak. The line cost is 83% of the base cost for this line type. 86% of the corridor is in mountainous terrain. It crosses 1 rivers (Clark Fork), It does not cross any major roads. It follows existing transmission line corridors for 100% of its length.

It crosses the following environmentally sensitive areas: 0% highly sensitive, 41% moderately sensitive and administratively protected, and 88% known conservation value. There are 0 acres federally recognized tribal lands within 5 miles. It crosses 3 counties (Mineral County, Sanders County, Shoshone County), and 69% of the line occurs on federal (BLM, USFS) land. Along the route, the locations with highest fair market real estate land value are in XX counties. 13% of the corridor is in high-wildfire risk areas. The segments with the highest slope (>45 deg) are at the northeastern end near Thomson Falls.

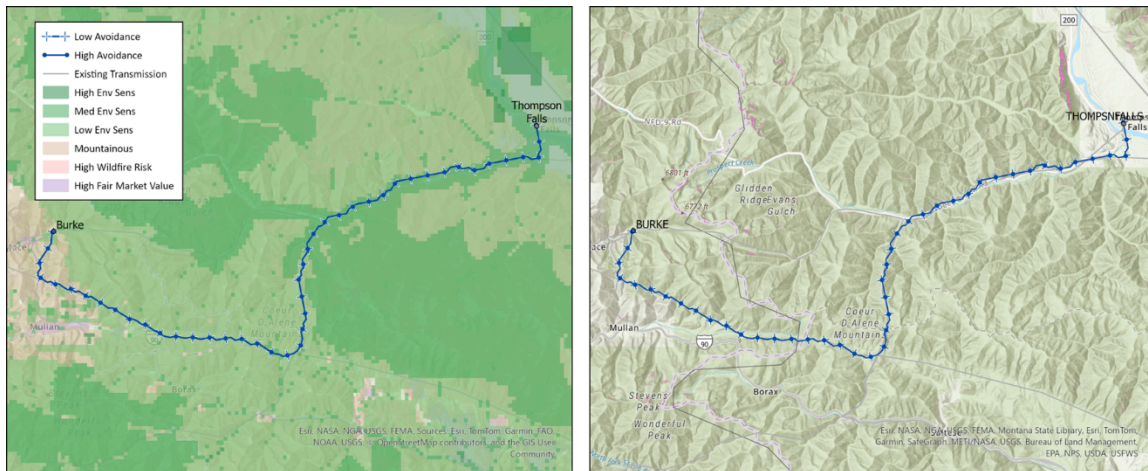


Figure 26. Thomson Falls to Burke

### Thomson Falls to Burke: Wind Candidate Project Areas

Table 20. Wind Candidate Project Area within 15 mi of Thomson Falls to Burke, low and high avoidance scenarios

Scenario	Wind CPA (GW)
Low Avoidance	0.2
High Avoidance	0.0

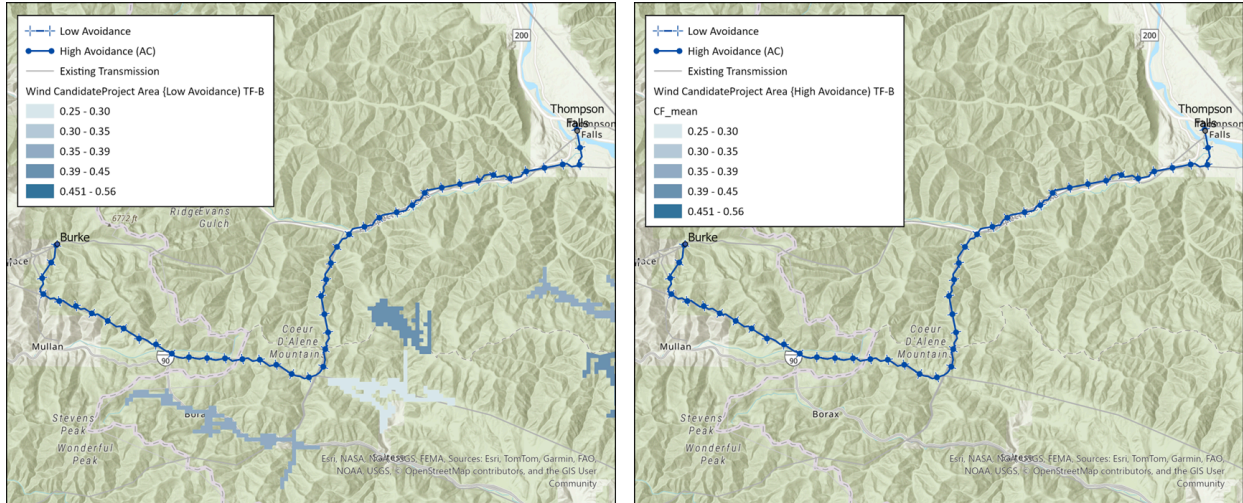


Figure 29. Wind Candidate Project Area within 15 mi of Thompson Falls to Burke, low and high avoidance scenarios

### Great Falls to Broadview

The GTF 230SWYD to BROADVIEW line is a 230 kV reconductor line, 169 mi long, running from Great Falls southeast to Broadview, partially following the Hwy 87 corridor, staying north of Lewis and Clark National Forest. The line cost is 131% of the base cost for this line type. 8% of the corridor is in mountainous terrain. It crosses 7 rivers (Clark Fork, Flathead River, Little Bitterroot River, Thompson River), and crosses 3 major roads (US Hwy 12, US Hwy 191, US Hwy 87). It follows existing transmission line corridors for 100% of its length, as it is a reconductor project.

It crosses the following environmentally sensitive areas: 1% highly sensitive, 32% moderately sensitive and administratively protected, and 45% known conservation value. There are 0 acres federally recognized tribal lands within the corridor, and 0 acres of tribal land within 5 miles. It crosses 6 counties (Cascade County, Golden Valley County, Judith Basin County, Stillwater County, Wheatland County, Yellowstone County), and it does not cross any federal land. Along the route, the locations with highest fair market real estate land value are at the northwestern terminus around Great Falls. 0% of the corridor is in high-wildfire risk areas. There are no segments with the highest slope (>45 deg).

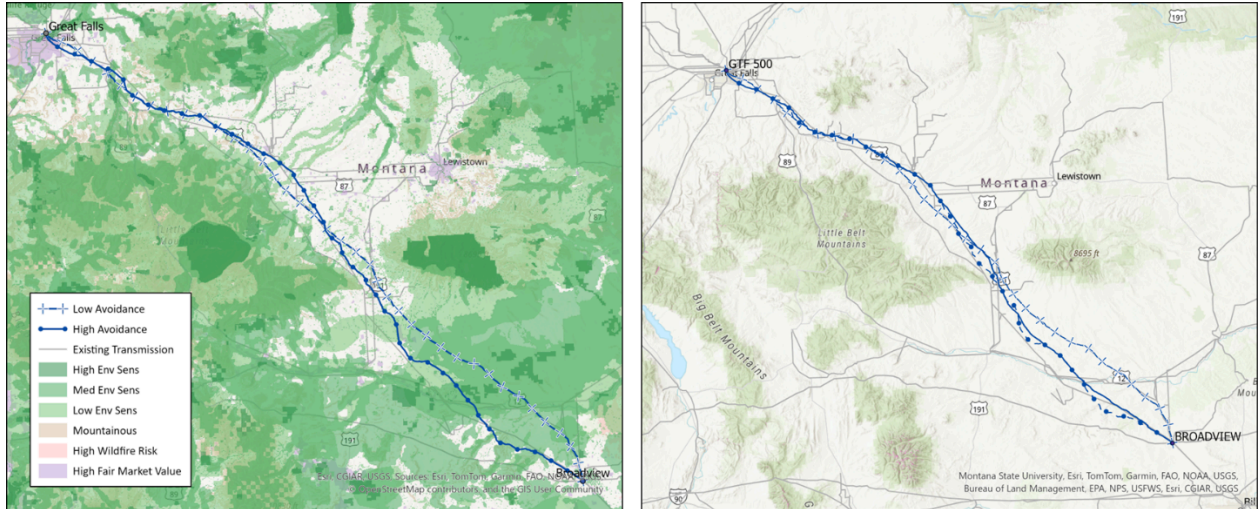


Figure 27. Great Falls to Broadview

### *Ovando to Placid Lake*

The OVANDO to PLACID LAKE line is a 230 kV reconductor line, 30 mi long, running from Ovando west along the Blackfoot river to Placid Lake. The line cost is 152% of the base cost for this line type. 38% of the corridor is in mountainous terrain. It crosses 1 rivers (Clearwater) near Blanchard Flats, It does not cross any major roads. It follows existing transmission line corridors for 100% of its length, since it is a reconductor project.

It crosses the following environmentally sensitive areas: 57% highly sensitive, 100% moderately sensitive and administratively protected, and 100% known conservation value. There are 0 acres federally recognized tribal lands within the corridor, and 194 acres of tribal land within 5 miles. It crosses 2 counties (Missoula County, Powell County), and 7% of the line occurs on federal (BLM, USFS) land. Along the route, the majority of the line is in areas with highest fair market real estate land value, along the Blackfoot River and around Placid lake. 86% of the corridor is in high-wildfire risk areas. The segments with the highest slope (>45 deg) are in Missoula county at the south end of Salmon lake.

It is one of the top few higher cost lines at 152% of base cost on a per-mile basis.

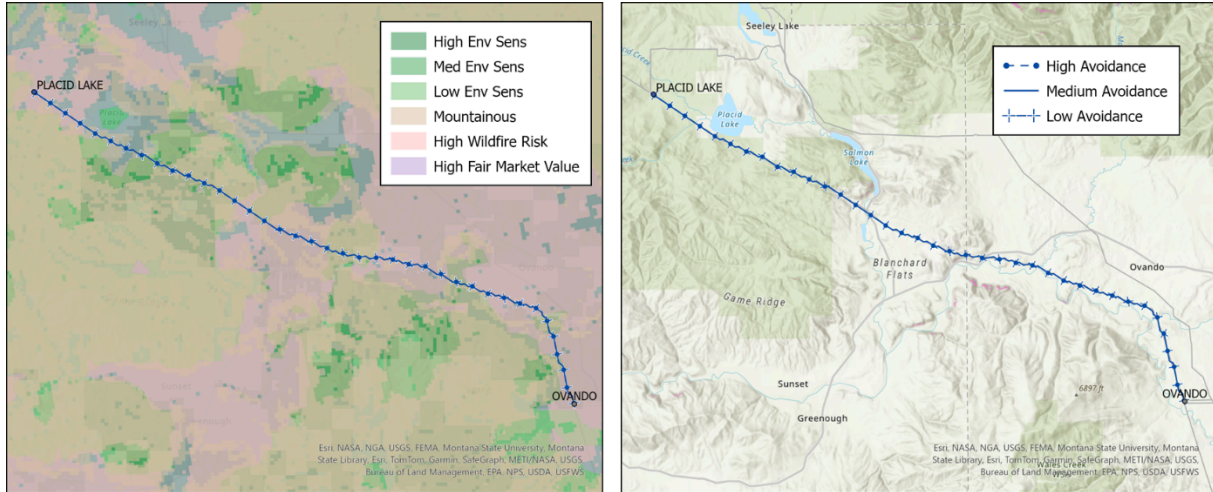


Figure 28. Ovando to Placid Lake overlaid with terrain features (left) and simple topo map (right)

### Ovando to Placid Lake: Wind Candidate Project Areas

Table 20. Wind Candidate Project Area within 15 mi of Ovando to Placid Lake, low and high avoidance scenarios

Scenario	Wind CPA (GW)
Low Avoidance	2
High Avoidance	0

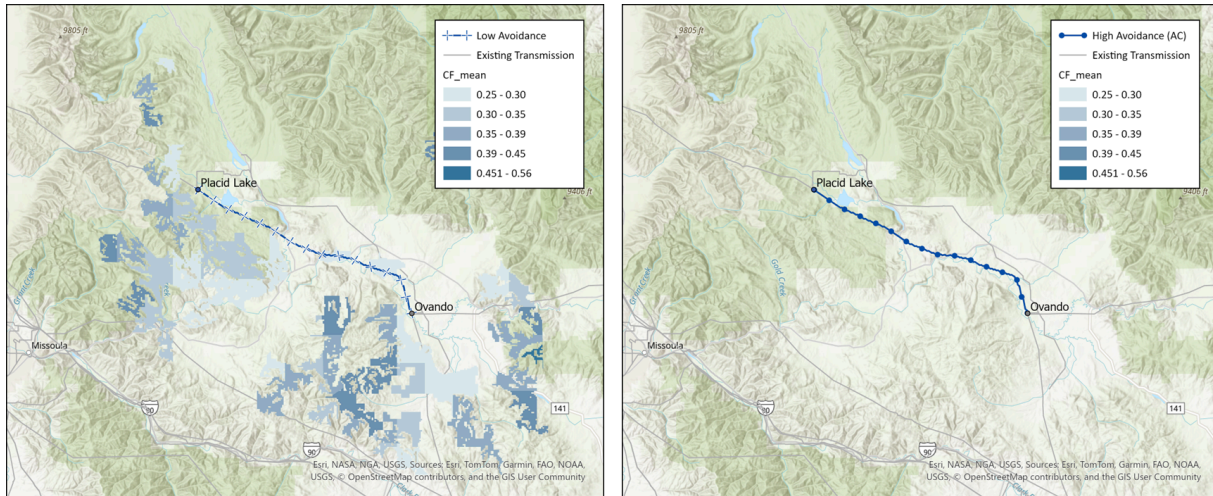


Figure 29. Wind Candidate Project Areae within 15 mi of Ovando to Placid Lake, low and high avoidance scenarios

### Garrison to Taft

The GARRISON to TAFT line is a 500 kV reconductor line, 182 mi long. It starts at Garrison substation near Deer Lodge, then runs northwest through Grass Valley, following the Clark fork river to pass north of Missoula, east of Evaro, north through Jocko Valley, crosses the Little Bitterroot river in Camas Prairie Basin, then follows the Clark Fork west through Thompson Falls to Taft. The line cost is 136% of the base cost for this line type. 57% of the corridor is in mountainous terrain. It crosses the Sapphire range and the Cabinet mountains, crosses 4 rivers (Clark Fork, Río Flathead, Río Little Bitterroot, Río Thompson), and crosses 3 major roads (US Hwy 93, I- 90, US Hwy 12). It follows existing transmission line corridors for 100% of its length, since it is a reconductor project.

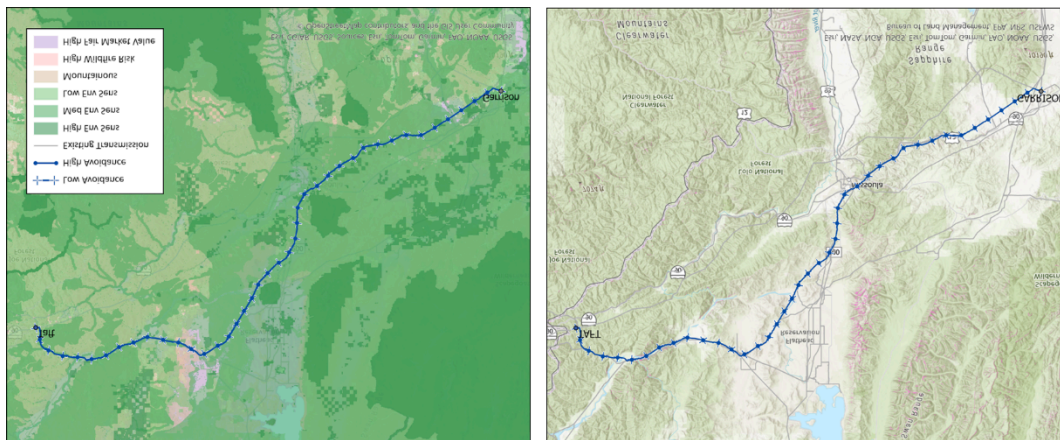


Figure 29. Garrison to Taft

### Garrison to Taft: Wind Candidate Project Areas

Table 20. Wind Candidate Project Area within 15 mi of Garrison to Taft, low and high avoidance scenarios

Scenario	Wind CPA (GW)
Low Avoidance	7
High Avoidance	0

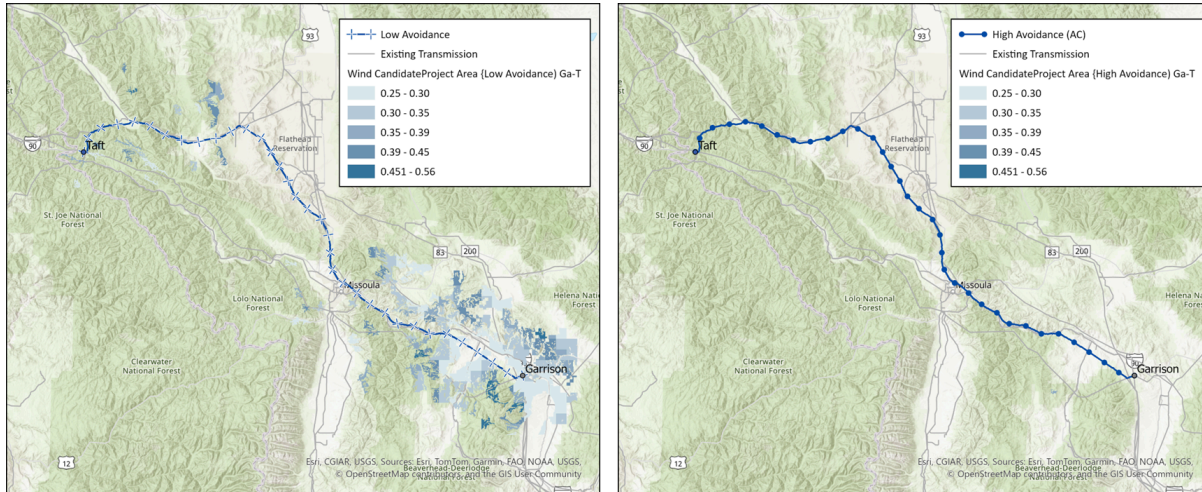


Figure 29. Wind Candidate Project Areae within 15 mi of Garrison to Taft, low and high avoidance scenarios

### Taft to Bell

The TAFT to BELL\_BPA line is a 500 kV reconductor line, 97 mi long, running from the Taft substation in the Couer D'Alene mountains west along the I-90 corridor crossing the Couer D'Alene river at Cataldo, running north of Couer Dalene lake, flowing along the north side of the Spokane river to terminate at the Bell substation in northern Spokane. The line cost is 151% of the base cost for this line type. 40% of the corridor is in mountainous terrain. The eastern half is mostly mountains; it crosses 2 rivers (Río Coeur d'Alene, Río Coeur d'Alene), and crosses 3 major roads (I- 90, US Hwy 95, US Hwy 95). It follows existing transmission line corridors for 100% of its length.

It crosses the following environmentally sensitive areas: 0% highly sensitive, 9% moderately sensitive and administratively protected, and 9% known conservation value. There are 0 acres federally recognized tribal lands within the corridor, and 0 acres of tribal land within 5 miles. It crosses 4 counties (Kootenai County, Mineral County, Shoshone County, Spokane County), and 74% of the line occurs on federal (BLM, USFS) land. Along the route, the locations with highest fair market real estate land value are on the western half of the line, in agricultural and medium intensity developed areas around Spokane. 0% of the corridor is in high-wildfire risk areas. There are no segments with the highest slope (>45 deg).

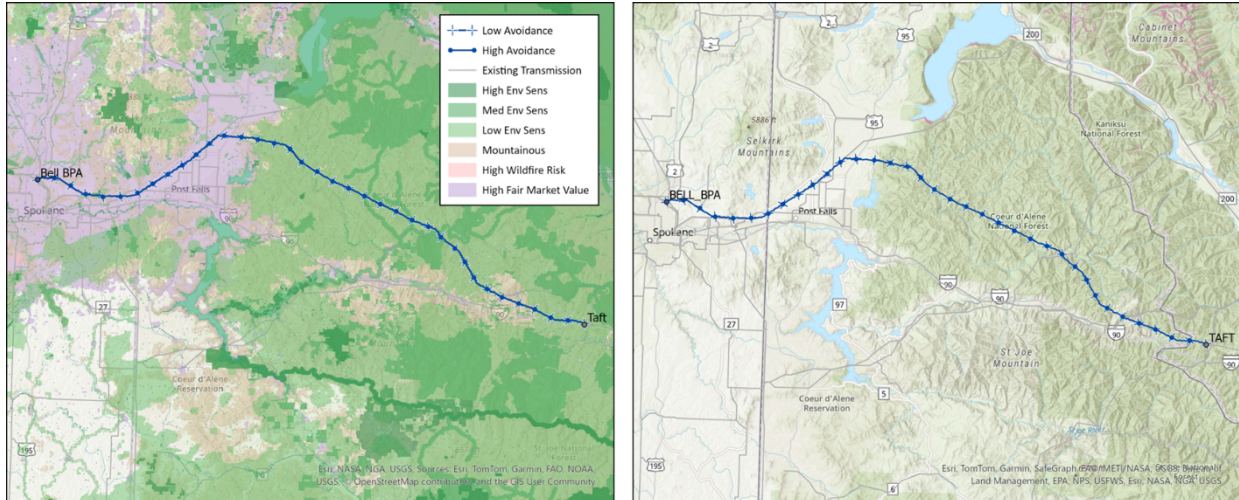


Figure 30. Taft to Bell reconductor

### Taft to Bell reconductor: Wind Candidate Project Areas

Table 20. Wind Candidate Project Area within 15 mi of Taft to Bell reconductor, low and high avoidance scenarios

Scenario	Wind CPA (GW)
Low Avoidance	
High Avoidance	

Figure 29. Wind Candidate Project Area within 15 mi of Taft to Bell reconductor, low and high avoidance scenarios

### Taft to Dworshak

The TAFT to DWORSHAK line is a 500 kV reconductor line, 94 mi long, running from Taft substation in the Couer D’Alene Mountains south to the Dworshak substation west of the Dworshak reservoir. The line cost is 125% of the base cost for this line type. 69% of the corridor is in mountainous terrain. It crosses the Couer D’Alene mountains, crosses 2 rivers (Río Saint Joe, Río Saint Regis), and crosses 1 major roads (I- 90). It follows existing transmission line corridors for 100% of its length, being a reconductor project.

It crosses the following environmentally sensitive areas: 1% highly sensitive , 21% moderately sensitive and administratively protected , and 21% known conservation value . There are 352 acres federally recognized tribal lands within the corridor, and 901 acres of tribal land within 5 miles. It crosses 4 counties (Clearwater County, Latah County, Mineral County, Shoshone County), and 42% of the line occurs on federal (USFS) land. Along the route, the locations with highest fair market real estate land value are in Clearwater County Idaho, near Teakean Butte.

12% of the corridor is in high-wildfire risk areas. The segments with the highest wildfire risk are in Latah county Idaho, near the Potlatch river. There are no segments with the highest slope (>45 deg).

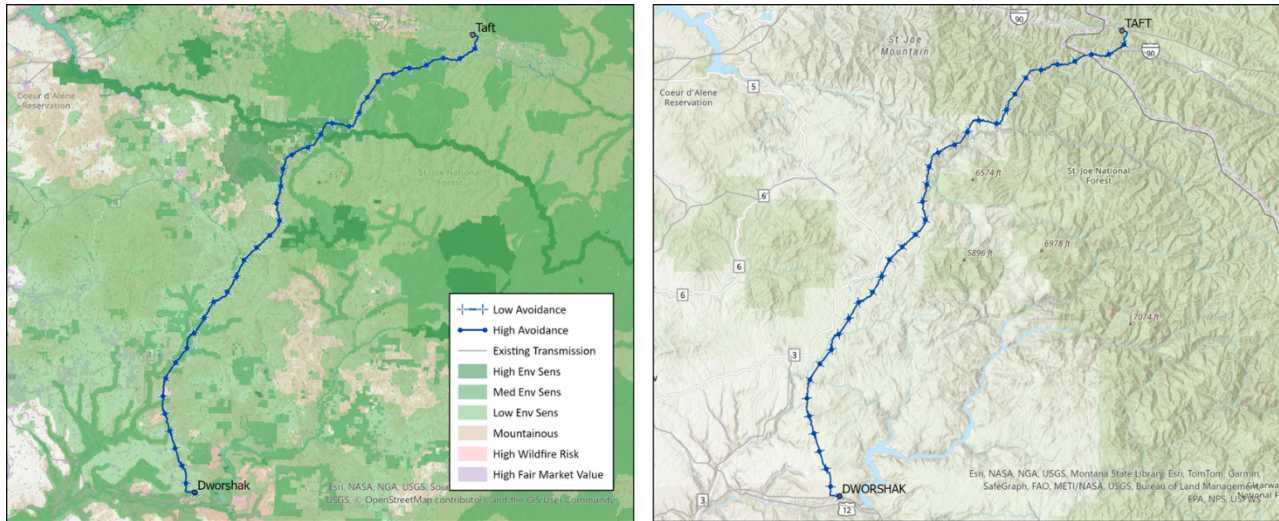


Figure 31. Taft to Dworshak

### Taft to Dworshak: Wind Candidate Project Areas

Table 20. Wind Candidate Project Area within 15 mi of Taft to Dworshak, low and high avoidance scenarios

Scenario	Wind CPA (GW)
Low Avoidance	3.0
High Avoidance	0.1

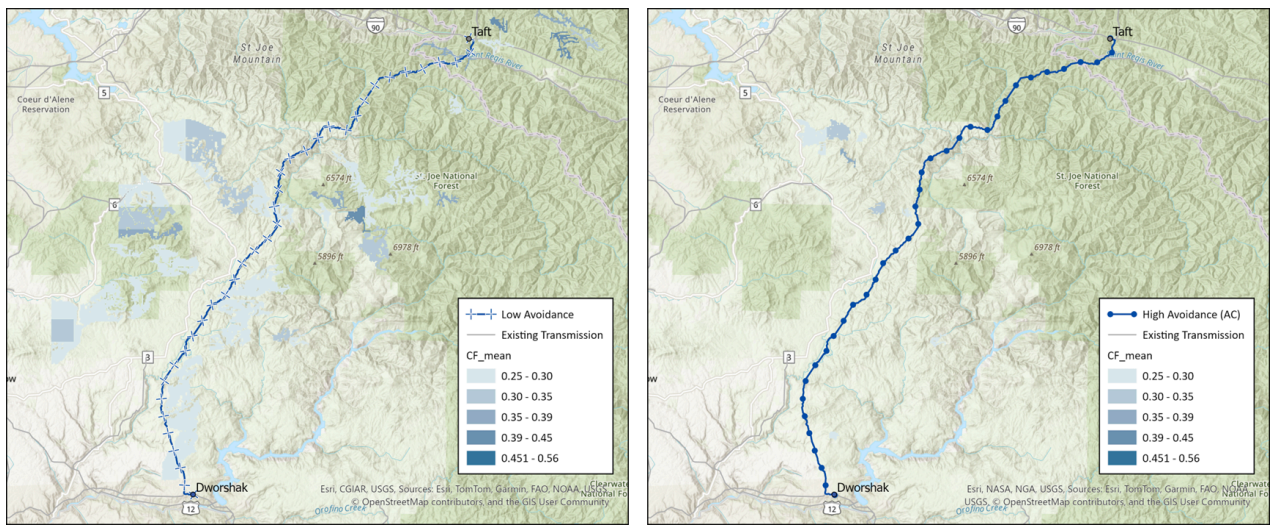


Figure 29. Wind Candidate Project Areae within 15 mi of Taft to Dworshak, low and high avoidance scenarios

## High Deployment Scenario

The high deployment scenario consists of 15 lines, summarized by type and length in the table below (medium avoidance of environmental impacts)

From Name	To Name	Upgrade Type	Voltage	Shape Length (mi)	Line cost terrain only (\$m/mi)	Percent of base cost
GARRISON	LIT_GOS	New Line	500	294	6.0	146%
TAFT	BELL_BPA	New Line	500	97	6.2	151%
BELL_BPA	ASHE	New Line	500	138	4.8	118%
GTF 500	BROADVIEW	New Line	500	162	5.1	123%
TAFT	HATWAI	New Line	500	112	6.4	157%
GTF 500	TAFT	New Line	500	263	9.3	226%
COLSTRIP 500	TOWNSEND	New HVDC Line	500	262	3.4	137%
GARRISON	TAFT	Reconductor	500	182	1.1	136%
OVANDO	PLACID LAKE	Reconductor	230	30	0.6	152%
TAFT	BELL_BPA	Reconductor	500	102	0.6	78%
GTF 230SWYD	BROADVIEW	Reconductor	230	169	0.5	131%
TAFT	DWORSHAK	Reconductor	500	94	1.0	125%
DWORSHAK	HATWAI	Reconductor	500	30	1.3	158%
THOMPSONFALLS	BURKE	Reconductor	115	32	0.3	83%
TOWNSEND	MIDPOINT	Reconductor	500	432	1.1	127%

Many of the lines in this scenario have been described previously in the medium deployment scenario. Additional projects are characterized below.

### *Taft to Hatwai*

The TAFT to HATWAI line is a 500 kV new ac line, 112 mi long, running from Taft in the St Joe National Forest just north of I-90 and southwest of Thompson Falls Montana, descending

southwest through the mountains of northern Idaho to the Hatwai substation at Lewiston just north of the Clearwater river. The line cost is 157% of the base cost for this line type. 51% of the corridor is in mountainous terrain. It runs just south of St Joe Mountain, through the Hoodoo Mountains, crosses 3 rivers (Río Saint Joe, Río Saint Maries, Río Saint Regis), and crosses 1 major road (I- 90). It follows existing transmission line corridors for 26% of its length.

It crosses the following environmentally sensitive areas: 0% highly sensitive, 20% moderately sensitive and administratively protected, and 20% known conservation value. There are 1127 acres of federal recognized tribal land within 5 miles, mostly at the southernmost terminus near Hatwai. It crosses 5 counties (Benewah County, Latah County, Mineral County, Nez Perce County, Shoshone County), and 32% of the line occurs on federal (USFS) land. Along the route, the locations with highest fair market real estate land value are in Latah County near Dry Ridge for example. None of the corridor is in high-wildfire risk areas. The segments with the highest slope (>45 deg) are in Shoshone county, near the crossing of the St Joe and St Regis rivers.

It is one of the top few higher cost lines, at 157% of base cost on a per-mile basis.

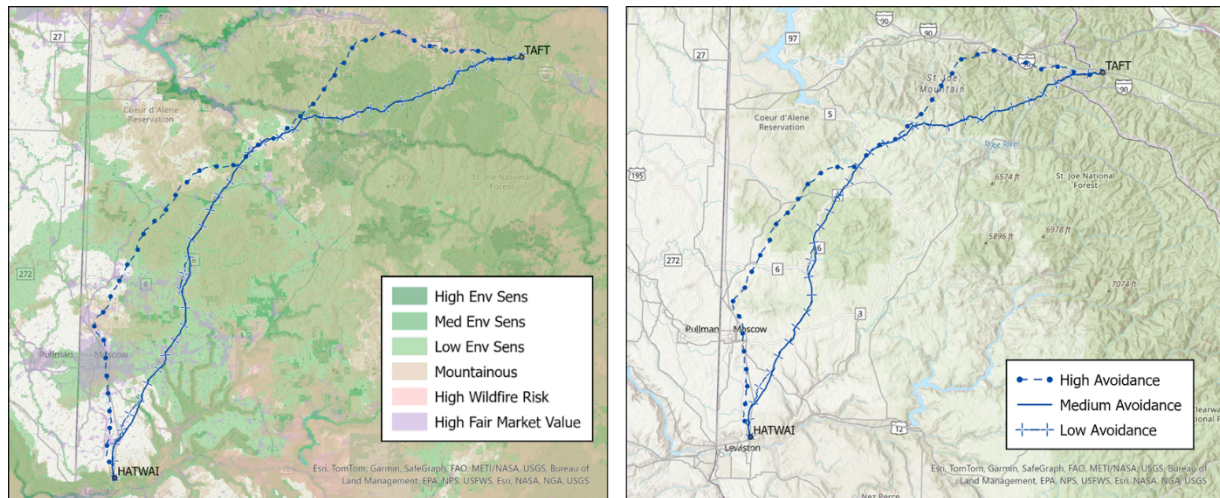


Figure 32. Taft to Hatwai, overlaid with terrain features (left) and simple topo map (right)

### Taft to Hatwai: Wind Candidate Project Areas

Table 20. Wind Candidate Project Area within 15 mi of Taft to Hatwai, low and high avoidance scenarios

Scenario	Wind CPA (GW)
Low Avoidance	6
High Avoidance	3

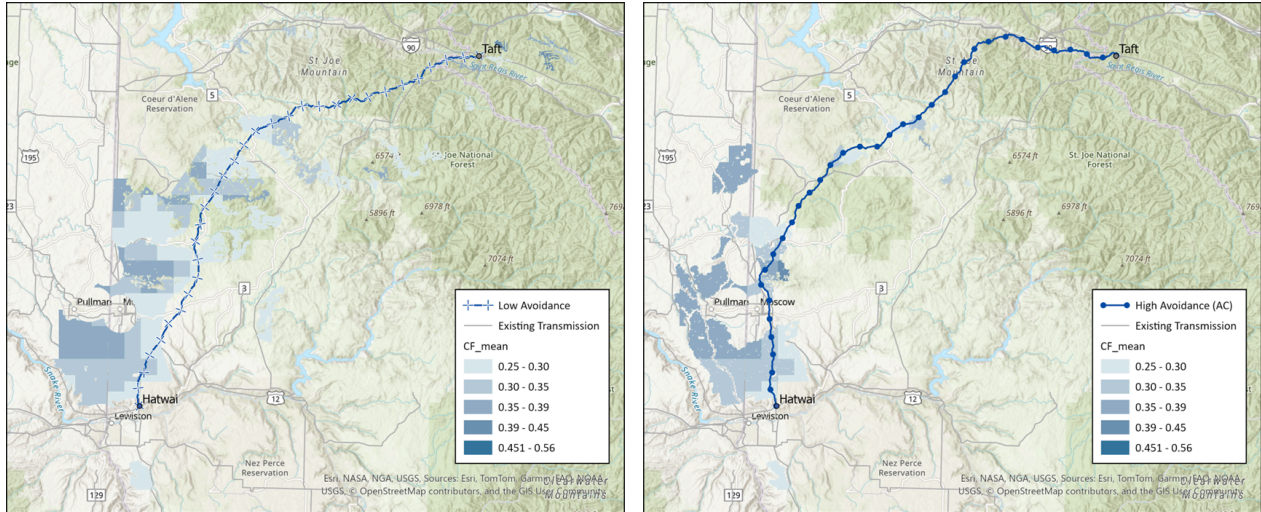


Figure 29. Wind Candidate Project Area within 15 mi of Taft to Hatwai, low and high avoidance scenarios

### Colstrip to Townsend

The COLSTRIP 500 to TOWNSEND line is a 500 kV new hvdc line line, 262 mi long, running west from the Colstrip substation in Rosebud County, through relatively flat terrain past the Broadview substation to the Townsend substation just south of Canyon Ferry Lake near the city of Helena. The line cost is 137% of the base cost for this line type. 6% of the corridor is in mountainous terrain, mostly at the western end. It crosses the Big Belt mountains, crosses 6 rivers (Arroyo Tullock, Arroyo Sarpy, Río Bighorn, Arroyo Fish, Río Yellowstone, Río Musselshell), and crosses 5 major roads (I- 94, US Hwy 12, US Hwy 191, US Hwy 87, US Hwy 89). It follows existing transmission line corridors for 34% of its length.

It crosses the following environmentally sensitive areas: 0% highly sensitive, 49% moderately sensitive and administratively protected, and 49% known conservation value. There are 0 acres federally recognized tribal lands within the corridor, and 5979 acres of tribal land within 5 miles mostly at the eastern end in Bighorn County. It crosses 8 counties (Big Horn County, Broadwater County, Golden Valley County, Meagher County, Rosebud County, Stillwater County, Wheatland County, Yellowstone County), and 4% of the line occurs on federal (BLM, LG, USFS) land. Along the route, the locations with highest fair market real estate land value are in Yellowstone County (along the Yellowstone River) and Broadwater County near the Townsend substation and the Missouri River. 10% of the corridor is in high-wildfire risk areas. The segments with the highest wildfire risk are in Yellowstone County just north of Billings, and Bighorn County around Sarpy Creek. There are no segments with the highest slope (>45 deg).

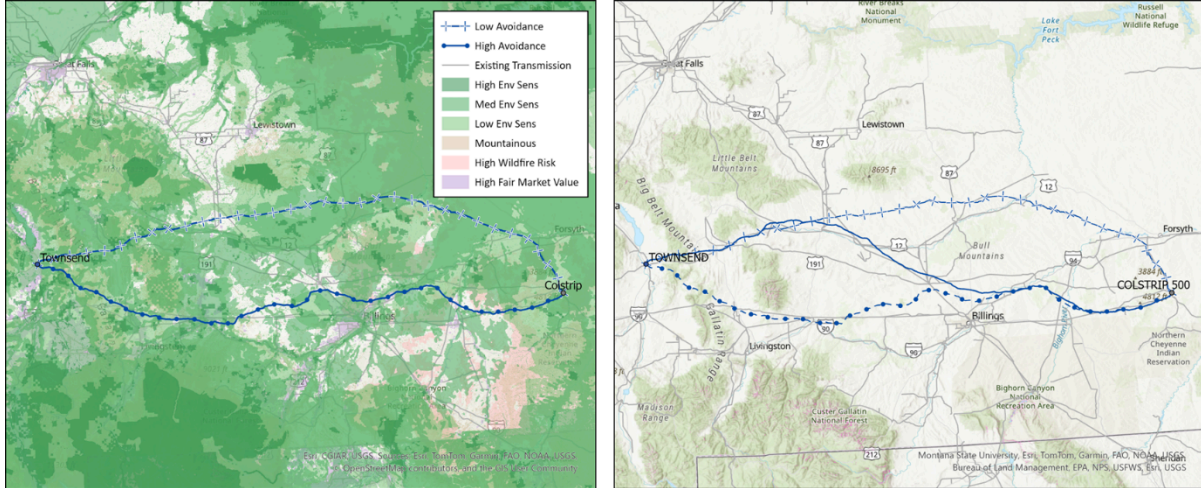


Figure 33. Colstrip to Townsend

### Colstrip to Townsend: Wind Candidate Project Areas

Table 20. Wind Candidate Project Area within 15 mi of Colstrip to Townsend, low and high avoidance scenarios

Scenario	Wind CPA (GW)
Low Avoidance	40
High Avoidance	4

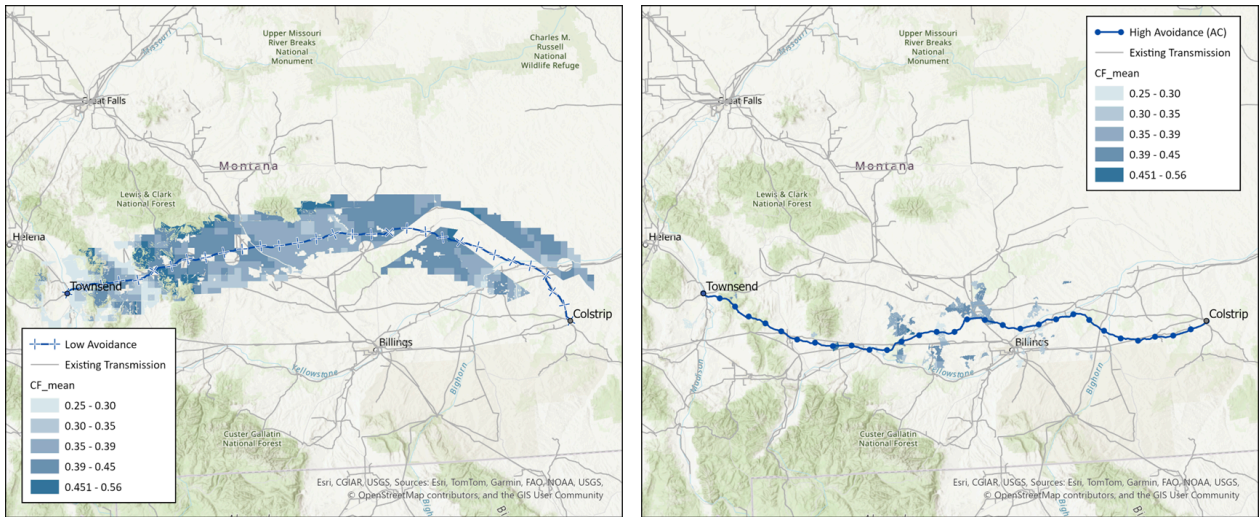


Figure 29. Wind Candidate Project Areae within 15 mi of Colstrip to Townsend, low and high avoidance scenarios

### Dworshak to Hatwai

The DWORSHAK to HATWAI line is a 500 kV reconductor line, 30 mi long, running from Dworshak just west of the Dworshak reservoir to Hatwai near Lewiston Idaho, paralleling the

Clearwater river about a mile to the north. The line cost is 158% of the base cost for this line type. 86% of the corridor is in mountainous terrain. It runs along the south side of Cream ridge, Potlatch ridge, and Green knob, crosses 1 rivers (Potlatch River), It does not cross any major roads. It follows existing transmission line corridors for 100% of its length, since it is a reconductor project.

It crosses the following environmentally sensitive areas: 0% highly sensitive, 64% moderately sensitive and administratively protected, and 55% known conservation value. There are 2949 acres federally recognized tribal lands within 5 miles. It crosses 2 counties (Clearwater County, Nez Perce County), and it does not cross any federal land. Along the route, the locations with highest fair market real estate land value are at the eastern end near Lenore, Wheeler Canyon, and Big George. 53% of the corridor is in high-wildfire risk areas. The segments with the highest wildfire risk are largely the same as the high value land areas, with the addition of the Howard Gulch area farther west. The segments with the highest slope (>45 deg) are also around Howard Gulch.

This is one of the top few higher cost lines, at 158% of base cost on a per-mile basis.

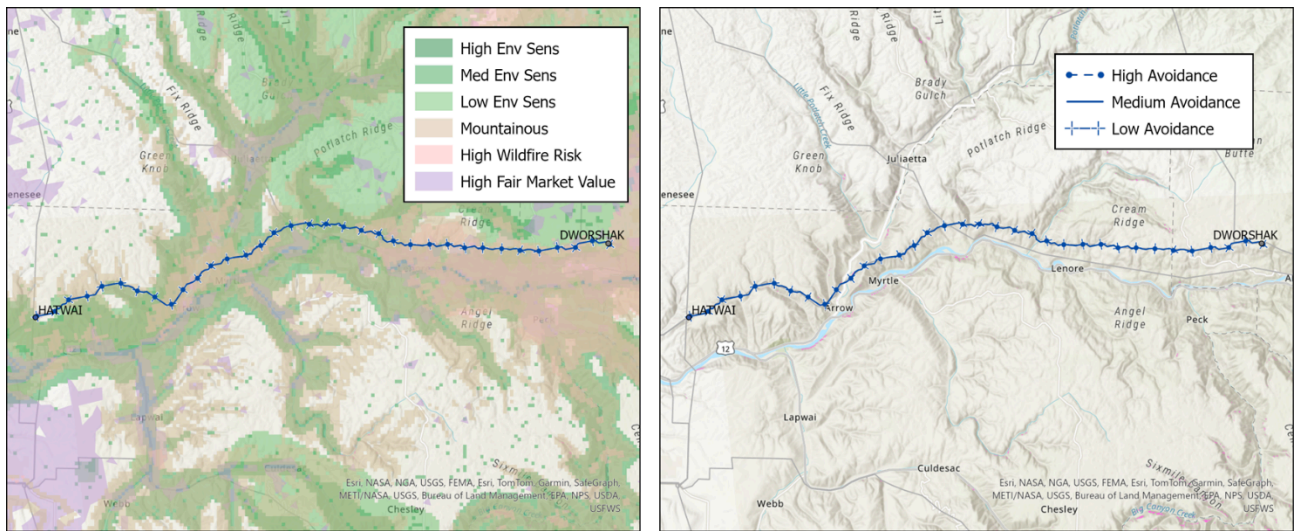


Figure 35. Dworshak to Hatwai overlaid with terrain features (left) and simple topographic map (right)

### Dworshak to Hatwai: Wind Candidate Project Areas

Table 20. Wind Candidate Project Area within 15 mi of Dworshak to Hatwai, low and high avoidance scenarios

Scenario	Wind CPA (GW)
Low Avoidance	2
High Avoidance	1

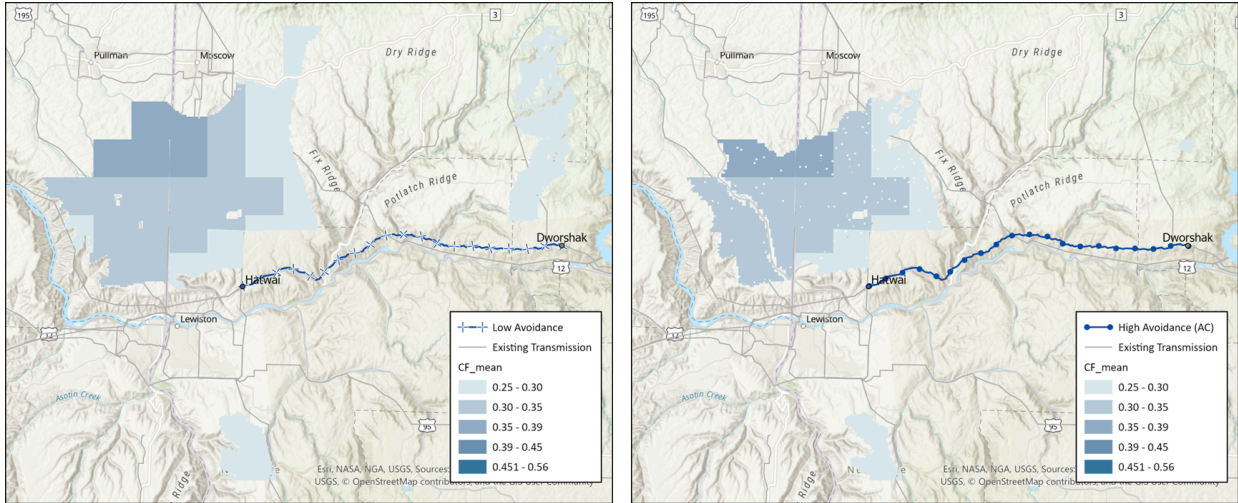


Figure 29. Wind Candidate Project Area within 15 mi of Dworshak to Hawaii, low and high avoidance scenarios

### Townsend to Midpoint (reconductor)

The TOWNSEND to MIDPOINT line is a 500 kV reconductor line, 432 mi long, running from Townsend near the city of Helena, to Midpoint near the city of Twin Falls Idaho. The line cost is 127% of the base cost for this line type. The terrain is the same as previously described in the low-deployment scenario.

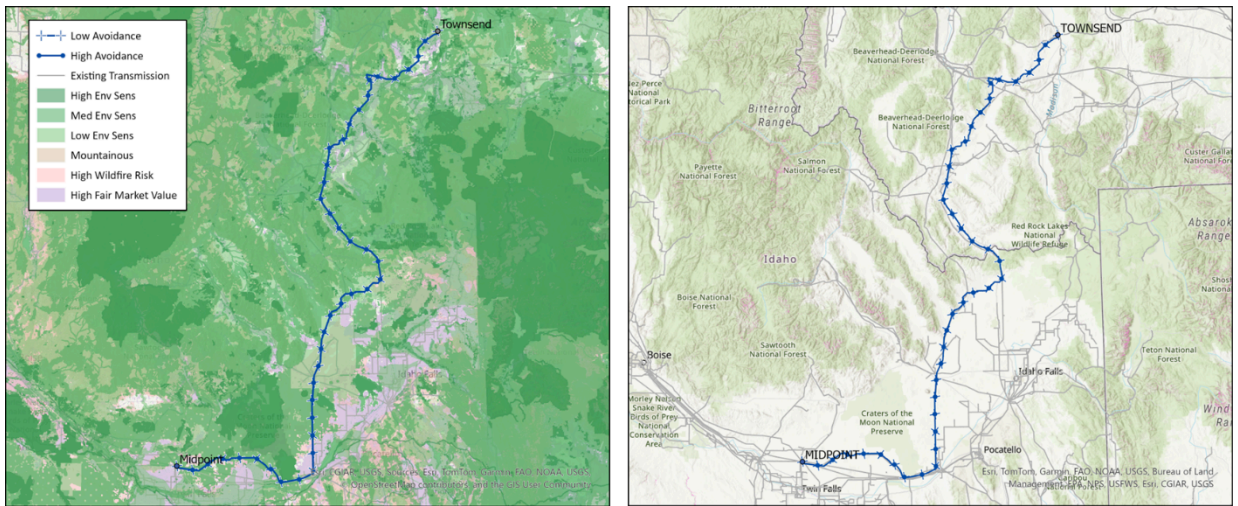


Figure 36. Townsend to Midpoint (reconductor)

