Integrating Environmental Criteria into Alignment Selection

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Abstract

Alignments of infrastructure projects such as pipelines and roads are often selected using only engineering and economic criteria. Consideration of environmental issues is postponed until a selected alignment is evaluated in an environmental document or permit application. However, many affordable and buildable projects have been stopped by the environmental documentation or permitting process, or by public opposition. If environmental issues were integrated into the initial alignment evaluation and selection process, considerable effort could be saved. This paper discusses how natural resources and community issues can be integrated with typical design issues into a cohesive, engineering-environmental evaluation process.

Introduction

Alignments of infrastructure projects such as pipelines and roads are often selected using only engineering and economic criteria. Primary considerations include topography, geotechnical conditions, constructibility, and cost. Consideration of environmental issues such as damage to biological habitat and cultural resources, or disruption of community activities from construction traffic, noise and dust, is postponed until a selected alignment is evaluated in an environmental document or permit application. The rationale is that engineering issues can make an alignment infeasible, while environmental issues can be handled by providing mitigation and other improvements.

However, many affordable and buildable projects have been stopped by the environmental documentation or permitting process, or by public opposition. If environmental issues were integrated into the initial alignment evaluation and selection process, considerable effort could be saved. This paper discusses how natural resources and community issues, which are typically viewed as qualitative, can be integrated with design considerations into a cohesive, engineering-environmental evaluation process.

Project Justification

One of the first environmental considerations that should be incorporated into the alignment selection process is project justification, or "purpose and need." This is a key component of environmental documents. The benefits provided and problems solved by implementing the project must offset the costs, inconveniences, and impacts if decision makers are to certify the document and approve the project.

Within and outside of the environmental documentation process, affected stakeholders have a prominent voice and powerful influence. Stakeholders may include adjacent landowners, nearby residents, and representatives of environmental or community groups. If these stakeholders are affected negatively by the project, they will not want to discuss project features or benefits until they are satisfied that the project is needed. This means that project goals must be clear. Factual documentation of project need, and the ramifications of not implementing the proposed project should be provided in writing. Also, alternatives to the proposed infrastructure should be explored. This foundation should be established before the first public information meeting.

Evaluation Criteria

The first step in developing an integrated engineering-environmental evaluation process is to identify key evaluation criteria. The criteria should be measurable based on available data, should be specific to the project type and location, and should differentiate alternative alignments from each other and/or from the No Project alternative. The criteria should indicate the degree of difficulty the project proponent would experience in accomplishing construction, environmental compliance, permitting, and public acceptance. The criteria should reflect important engineering and environmental issues.

Examples of typical engineering criteria are utility conflicts, topography, access, right-of-way, alignment length, and construction cost. Environmental issues are often considered to be limited to biological resources, for example wetland habitats, wildlife corridors, and plant and animal species listed as threatened or endangered. While biological resources are important, environmental documents must address a wide range of natural resources and community issues, many of which are also appropriate to use in an alignment evaluation process. Other natural resources issues include water quality, archaeological sites, and mineral resources. Community issues include traffic disruption, aesthetics, compatibility with other projects or land uses, property ownership, flooding, and public sensitivity or controversy. Engineering issues that must be addressed in environmental documents include soil conditions, faults, landslides, liquefaction, and hazardous wastes.

The type and number of criteria appropriate for a particular evaluation process depends on many project-specific factors. Visualize the project being constructed and operated in each of the alternative locations and variations being evaluated. What kind of biological resources would be damaged or lost? Is there a nearby lake, reservoir, or stream that could be contaminated? Are prehistoric, historic, or Native American sites in the vicinity? Would the project interfere with active or potential future mining activities? How severely would traffic be disrupted? What would the project look like, and how would it change the local ambience? Would the project introduce a new land use, or conflict with future plans? Who owns the project property and adjacent lands? Would the project change existing flooding and drainage patterns? Has the public already formed an opinion about the project? Are the alternative project properties viewed as valuable space in their current condition? What kinds of soils, seismic, and contamination hazards exist in the alternative project locations? If the answers to these kinds of questions are different for different alternatives, the criteria could be useful in an evaluation. If the question is not relevant, or if the answer is the same for all alternatives, that criterion may not be useful. If no data are available to answer the question, it may not be possible to apply that criterion.

Criteria can be identified by a single project member, by the project team, or in a larger group. The criteria identification process, or at least review of the results, offers the opportunity for public and regulatory agency involvement. Criteria approval is an important step in achieving public support for the alternatives evaluation process, and ultimately, the project.

Weighting Criteria

The weights that engineering, natural resources, and community criteria carry can be derived simply from the number of criteria in each group, rather than by assigning a percentage weight. Below is an example of using the number of criteria to determine weight, applying the following criteria list:

- Natural Resources
  - Wetlands Habitat
  - Upland Habitat
  - Archaeological Sites
- Community
  - Private Properties
  - Aesthetics
- Engineering
  - Alignment Length
  - Construction Duration
  - Seismic Hazards
  - Construction Cost
  - Utility Conflicts

In this list, with each criterion counting equally, natural resources issues carry 30% of the ranking, community issues carry 20%, and engineering issues carry 50%. Natural resources and community issues combined as environmental issues carry 50%. Using the number of criteria to assign weight avoids controversy about the relative value or importance of environmental versus engineering criteria. For example, if a single criterion (such as cost), were assigned a relatively high weight in the evaluation (such as by having it count for 50% of the total evaluation score), the public may complain that environmental issues are being discounted. It is easier to have an objective discussion about which criteria are relevant and which are not, rather than subjective arguments about how much weight various criteria should have in the evaluation score. To make cost, which is certainly an important consideration, carry more weight in the evaluation, several criteria that represent different aspects of cost could be identified. These could include total construction cost, ease of financing, opportunities for cost sharing, utility rate increases, and duration of payment period.

Evaluation Process

A matrix evaluation process can be very effective in incorporating a variety of criteria and comparing diverse alternatives. The matrix is composed of the evaluation criteria on one axis and the alternatives on the other. A rating procedure is then developed to assess how well each alternative performs in each criterion.

"High Score Wins" Evaluation. One possible rating procedure is where the highest score is the most desirable. In this process, performance ratings could range from 1 (poor performance) to 5 (excellent performance). Ratings are defined as quantitatively as possible so that analysis can be conducted using available data to the maximum extent. For example, the difficulty of constructing a pipeline within streets could be measured by the number of lanes in each street affected, because the greater the number of lanes, the more room available for construction without disrupting traffic flow. An example performance rating definition for number of lanes is as follows:

1 = There is only one lane in each direction on 80% or more of the alignment.
2 = There is only one lane in each direction on 50% to 79% of the alignment.
3 = There is only one lane in each direction on 20% to 49% of the alignment.
4 = There are two or more lanes in each direction on 81% to 90% of the alignment.
5 = There are two or more lanes in each direction on more than 90% of the alignment.

Some impacts, such as aesthetics, are less quantifiable. In these cases, definitions must include more judgement. An example performance rating definition for impacts to aesthetics is as follows:

1 = The project would include a new above-ground facility in a visually sensitive area, and the facility appearance would be intrusive.
2 = The project would include a new above-ground facility in a visually sensitive area, but the appearance would be compatible with the surroundings.
3 = The project would include a new above-ground facility, but the surroundings are not visually sensitive and the appearance would be compatible with the surroundings.
4 = The project would include minimal above-ground facilities, but underground construction would require permanent changes in existing topography.
5 = The project would include minimal above-ground facilities, and all areas disturbed by project construction could be restored to original or better conditions.

Another qualitative issue is compatibility of the proposed project with other projects that have already been implemented or are in the planning stages. An example performance rating definition for compatibility with other projects is as follows:

1 = The proposed project would be mutually exclusive with an existing or planned project.

2 = The proposed project would complicate or interfere with more than three other projects.

3 = The proposed project would complicate or interfere with two or three other projects.

4 = The proposed project would complicate or interfere with one other project.

5 = The proposed project would generate opportunities for enhancement or joint implementation of other projects, and would not complicate or interfere with any other projects.

Performance rating definitions for other criteria could relate to areas or lengths impacted, costs for construction or mitigation, percentage of alignment length with a particular desirable or undesirable characteristic, or distance of an alignment from a sensitive area. Performance ratings can be defined in relative or absolute terms. For example, construction cost could be defined as 1 being most expensive and 5 being least expensive of the alternatives evaluated, or as 1 through 5 being within certain dollar value ranges.

"**Implementation Difficulty" Evaluation**. Another type of rating procedure groups alignments into projects that would be relatively easy, moderately difficult, or extremely difficult to implement. For this process, performance ratings are defined to reflect the degree of implementation difficulty as low, medium, or high. The definitions are based on project team judgement about the likely level of difficulty the project proponent will experience in overcoming the challenges of each criterion. In this process, a high rating is undesirable. For example, the degree of difficulty in obtaining right of way could be indicated by the number of private properties crossed by the alternative alignments. An example performance rating definition for this issue is as follows:

Low = Fewer than five private properties crossed.

Medium = Five to fifteen private properties crossed.

High = More than fifteen private properties crossed.

This criterion could also indicate public controversy. Another indicator of potential public controversy is the public's sensitivity to construction in the alternative locations. An example performance rating definition for this issue is as follows:

Low = Benefits of the project are likely to be supported by the affected community.

Medium = Community issues are possible.

High = Community concerns are likely, given the affected community's past experience with construction in the area, or knowledge of impacts caused by similar projects.

Other performance rating definitions could be based on shortest (low difficulty) to longest (high difficulty) alignment length, least (low difficulty) to most (high difficulty) area of wetlands impacted, or cheapest (low difficulty) to most expensive (high difficulty) construction cost. These types of definitions are relative, in that they compare the alternatives to each other. Absolute definitions could be developed using values for length, area, or cost that are independent of the values for the alternatives being examined.

Evaluation Results

Before applying the criteria and evaluation process, it is useful to seek concurrence from the affected community and interested stakeholders. The most objective situation is when everyone agrees the process is valid before they know the results. It is also useful to include the No Project alternative in the evaluation. Then the advantages and disadvantages of doing nothing will be clear to decision makers, the public, and the project proponent. In addition, analyzing the No Project alternative is a requirement of many environmental documents.

High Score Wins Evaluation. In this evaluation process, the highest scoring alternative is the project that offers the best balance of minimizing impacts to natural resources and the surrounding community, while maintaining sound engineering and economic feasibility. Total scores can be compared in terms of lowest to highest. Also, scores in groups of criteria can be compared. Sensitivity analysis can be conducted to examine the effect of eliminating or adding certain criteria.

Implementation Difficulty Evaluation. In this evaluation process, the number of low, medium, and high ratings achieved by each alternative must be analyzed. One possibility is to use the number of high implementation difficulty ratings as the key indicator. Assuming ten criteria, for example, an alternative could be classified as follows:

Relatively easy to implement =	Two or fewer high implementation difficulty ratings.
Moderately difficult to implement =	Three or four high implementation difficulty ratings.
Extremely difficult to implement =	Five or more high implementation difficulty ratings.

As with the High Score Wins evaluation process, ratings in groups of criteria can be compared, and sensitivity analyses can be conducted.

Applications

The High Score Wins process was applied to evaluate alignment alternatives for a pipeline project, and variations of a road/bridge widening project. In the pipeline project, the point spread was narrow, although there was clearly one alternative with the highest score. The total scores, which were based on 33 criteria, were similar because alternatives in urban locations had low scores in community issues and high scores in natural resources issues, while alternatives in undeveloped areas had the reverse scoring pattern. To further analyze the evaluation results, the criteria were regrouped into the following key issues: biological resources, cultural resources, earth resources, water resources, land use, traffic, public services, constructibility, and cost. Performance scores in these issue groups were then calculated and compared.

In the road/bridge project, a total of 40 criteria were applied. The point spread was wider in this analysis, and there was clearly one alternative with the highest score. One alternative had a lower total score than the No Project alternative, indicating it would be worse than doing nothing.

The Implementation Difficulty process was applied to evaluate the feasibility of constructing infrastructure maintenance routes in a number of canyons where no access currently exists. The object of this evaluation process was not to choose one alternative, but to determine which projects could be implemented quickly and which ones would be costly, difficult to permit, or controversial. This evaluation was based on ten key criteria.

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