# Balancing Transportation and First Nation Values
# Highway 11/17 Value Engineering Study

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**Abstract**

The Ministry of Transportation of Ontario (MTO) was holding onto a 70 ha parcel of property for the future construction of an interchange at the junction of Highways 11 and 17, part of the Trans-Canada Highway system. Red Rock Indian Band, located adjacent to the future interchange, had reached development capacity. The only opportunity for expansion was to obtain MTO lands that were being protected. The First Nation had made an urgent request to Ontario regarding expanding their land base.

MTO required a quick and comprehensive method to identify ultimate property requirements without updating the preliminary design and environmental assessment.

MTO invited the First Nation to participate in a modified Value Engineering study so they could share their ideas and values. The purpose of the study was to support the selection of the best value interchange configuration that would meet the needs of the highway users and First Nation.

The recommended innovative design avoided relocating the highway patrol yard. Constructability was enhanced by shifting the interchange away from the existing intersection, simplifying traffic management and improving worker safety. The recommended solution offers a $14.3 million savings over the original design.

This VE process demonstrated the benefits of including external stakeholders, such as First Nations. Most importantly, the First Nation gained an appreciation that a fair and transparent evaluation was used to select the preferred design while balancing transportation and First Nation values.

## 1. Introduction

The Ministry of Transportation of Ontario (MTO) completed a modified Value Engineering (VE) Study with full time participation of the Red Rock Indian Band (RRIB) [1]. This Ojibway First Nation is located in Northwestern Ontario, 100 km east of the City of Thunder Bay within the 1850 Robinson-Superior Treaty area as shown in Figure 1.

Due to residential and commercial growth RRIB's land base has reached full development capacity. The community's land base straddles Highway 11 just east of the City of Nipigon and is located north of the Highway 11/17 intersection. It is bounded by Lake Helen and the Nipigon River on the west, and constrained to the north and east by steep bedrock topography. Lot 14 south of RRIB appeared to be the only opportunity for contiguous expansion but was owned by the MTO. RRIB expressed interest in acquiring Lot 14.

At the time of the study, MTO was protecting the whole of Lot 14, for the future construction of an interchange at the intersection of Highways 11 and 17. This very important intersection forms the confluence of the two primary highways in Northwestern Ontario. The intersection provides a link to the remainder of Ontario, Eastern Canada and Western Canada.

By protecting the entire Lot 14 from development, MTO was maintaining flexibility for the future relocation of an existing highway patrol yard that was situated within Lot 14, ensuring that it would be in close proximity to the proposed interchange.

MTO's property requirements were conservatively based on a conceptual interchange preliminary design prepared during 1996 with the understanding that a design to relocate the existing highway patrol yard would be required at a later date.

When RRIB requested that MTO's surplus lands be made available for the communities expansion, MTO needed a quick, objective, and comprehensive method to identify ultimate property requirements without the benefit of an updated preliminary design and environmental assessment. Engineering solutions were required to achieve the optimum blend of highway development and surplus land.

## 2. Value Engineering Overview

VE is a creative, organized effort, which analyzes the requirements of a project for the purpose of achieving the essential functions at the lowest total cost (capital, operating, and maintenance) over the life of the project. VE is a systematic, organized approach to obtain optimum value for each dollar spent. Through a group investigation, using experienced, multi-disciplinary teams, value and economy are improved through the study of alternate design concepts, materials, and methods.

This approach has been used successfully on projects of all types and magnitudes and allows the VE Team to maintain a responsive turnaround while producing meaningful results. The approach also encourages owner and designer participation in the study in order to take advantage of their experience and knowledge. Application of the VE methodology and co-ordination of the study activities significantly increases the value of ideas presented and the implementation of recommendations. The VE process provides recommendations that are built on consensus, transparency and respect.

## 3. Value Engineering Study

A VE study was commissioned to update and assess MTO's proposed future plans to reconstruct Highway 17 as a four lane Controlled Access Highway and protect property for an interchange. The objectives of the VE Study included:

- More accurately assessing MTO's future property needs at the junction of Trans-Canada Highways 11 and 17 near RRIB based on an interchange configuration meeting controlled access highway criteria.
- Assessing the feasibility, practicality, cost, and implications to maintenance operations and public safety of alternate locations of the highway patrol yard, both inside and outside of Lot 14.
- Optimizing the use of Lot 14, in the context of the above objectives, to maximize and define the opportunity for expansion of the RRIB community.
- Developing VE Proposals to obtain overall capital cost savings, life cycle cost savings and/or improved project performance while still achieving the functional requirements of the project (best value for the money spent).
- Combining VE Proposals into overall project scenarios and evaluate those scenarios against the updated base case concept design to assist MTO in determining a preferred alternative to take forward.
- Providing new perspectives and creative ideas to the future interchange design.
- Identifying project risks and how they can be mitigated.

A multi-disciplined VE Team comprised of MTO, RRIB, and engineering consultants (MMM Group Limited, Faithful+Gould, McCormick Rankin Corporation) analyzed the project utilizing the VE job plan, as outlined on the following pages. Each step of the plan played an important part in achieving results, such as maintaining essential project functions at desired levels of performance and assuring eventual savings to MTO.

The Highway 17 interchange design depicted in the 1996 Preliminary Design Report is a fully directional trumpet interchange located at the existing tee intersection with Highway 11. Given the very conceptual nature of the interchange layout depicted in the Preliminary Design Report, the VE Team developed a more detailed concept to generally match the footprint. The refined concept was prepared in advance of the workshop and then utilized as the base case for the VE Study as shown in Figure 2.

MTO often involves technical stakeholders such as municipal representatives in a VE study. Even if stakeholders may not have previously been exposed to a VE workshop, most are familiar with the planning or design of roads and can readily participate in a technical capacity. The VE process was modified to accommodate a stakeholder (RRIB) who had not previously been involved in VE and did not have a background in planning roads.

The VE Study was organized into three distinct parts: Pre-Workshop, Workshop, and Post-Workshop as described below:

### 3.1 Pre-Workshop

The outcome of a VE Study is largely dependent on proper preparation. The success of the VE Study was due to the excellent co-ordination and co-operation between MTO, RRIB, and Consultants during the weeks prior to the workshop. Pre-workshop activities included:

- Teleconference meetings with MTO and Consultants to organize the VE Study, discussing the issues of this project, determining the project and VE workshop objectives, drafting project performance criteria and measures, and developing a facilitation plan to involve RRIB during the workshop.
- Meeting with MTO, RRIB, and Consultants to discuss the upcoming VE Study, obtain the values and perspectives of RRIB, and develop a collaborative relationship with RRIB. All participants were briefed on their role and responsibility during the study.
- Distributing a Pre-Workshop Information Package to the VE Team.
- Updating the base case design and preparing a parametric cost model for use in the workshop since the base case design and estimate were from a 1996 Preliminary Design Report. This cost model was used by the VE Team to determine cost implications of the various alternatives generated in the workshop.
- Preparing a draft Function Analysis Systems Technique (FAST) Diagram.

### 3.2 Workshop

During the workshop a Job Plan was followed, an organized approach for searching out high cost and potential value/performance improvement areas in the design and developing alternate solutions for consideration. The Job Plan utilized a multi-disciplinary VE Team to ultimately arrive at consensus regarding the recommendations for implementation.

Since the workshop included participants (RRIB) with little or no VE experience, the VE Team Leader gave a brief presentation to all participants on the overall reasons for and benefits of the VE process, as well as the techniques and expectations of each of the

VE Study phases. One of the benefits stressed was the ability of the VE Process to build consensus among varied stakeholders with differing perspectives to help obtain project alternatives that will satisfy the functional needs of those stakeholders at a reasonable cost.

The Workshop Job Plan utilized the following seven key phases:

### 3.2.1 Information

At the beginning of the VE workshop, it was important to understand the issues of the project and the background and decisions that have influenced the development of the base case conceptual design. On the first day of the five-day workshop, MTO and Consultants met with RRIB at their Resource Centre for the Information and Function Analysis Phases, followed by a site visit and tour of the RRIB community. After introductions, the VE Team Leader gave an introduction to VE and went over the workshop agenda and guidelines. Next, MTO presented the project issues and the objectives of the VE Study from the standpoint of MTO. The RRIB Chief, then discussed the project issues and objectives of the VE Study from their standpoint. Finally, the Consultant presented the conceptual design for the project and the parametric cost model. After the presentations, there was a discussion of the issues and objectives of the project, the objectives of the VE Study, and the constraints placed on the VE Team, followed by an engaging question and answer session.

The VE Team Leader hosted a discussion regarding project performance criteria and measures to be used during the workshop to evaluate creative ideas, various VE alternatives, and eventually, complete project scenarios. The VE Team identified project risks, mitigations measures and prepared a quantitative risk register.

The Information Phase ended with a site visit of Lot 14, including the proposed site for the future highway interchange and existing highway patrol yard. In addition, the Chief led a tour of the community that gave additional insight into their values and perspectives on the project.

### 3.2.2 Function Analysis

The most important step in the VE Job Plan, which separates VE from both the normal design process and simple cost reduction, is function analysis. A function is defined in a verb-noun statement that defines a key performance feature of the project. Function analysis helps the VE Team clearly understand the relationships of the functions to one another, and how they work together to satisfy the requirements of the project. A FAST diagram graphically illustrates the interrelationships of the project functions and is often invaluable in achieving this understanding.

The function logic concepts and rules for the FAST diagram were shared with the VE Team. After a lengthy discussion, some additional functions were added and some functions were rearranged until participants agreed on the resulting FAST diagram as shown in Figure 3.

The FAST Diagram shows that the basic function (performance feature that must be attained) for the Highway 11/17 intersection as derived from various planning documents, is “Control Access”. Due to the two design objectives, “Accommodate All Moves” and “Meet Design Standards”, the primary reason to undertake the VE Study is reflected in the functions “Protect Property” and “Identify Property Requirements”. By meeting the latter function now, the VE Study will “Minimize Impacts to RRIB” during the future project.

After reviewing the FAST diagram, the VE Team decided on a project component approach to the Creative Phase, selecting the performance criteria and weights as described below:

| | |
|---|---|
| Community Development Opportunities | 30% |
| Highway Patrol Yard Operations | 20% |
| Sustainability | 10% |
| Traffic Operations and Safety | 40% |

The performance measures include RRIB’s values such as community development opportunities and sustainability.

### 3.2.3 Creative

During this phase, the VE Team brainstormed as many ways as possible to achieve improved value for the value target areas. During the creative phase, a positive environment for brainstorming was maintained at all times, reserving all judgment of the ideas until the evaluation phase. The VE Team was looking for quantity and association of ideas, which would be evaluated in the next phase of the study. The more ideas generated, the more likely a “breakthrough” idea would be identified with significant value implications. Many of the ideas brought forth in the Creative Phase were a result of discussions throughout the Information Phase, during risk register development, and in the function analysis phase. Fifty-five ideas were generated.

### 3.2.4 Evaluation

Before proceeding with the Evaluation Phase, the VE Team reviewed and discussed the draft project performance criteria definitions and how each would be measured in the workshop. These performance criteria and measures would be refined several more times before their final use at the end of the Scenario Development Phase.

During the Evaluation Phase, the VE Team judges the ideas resulting from the creative session. RRIB gained a better understanding of the engineering standards and constraints that impact the feasibility of various ideas through the evaluation process. The evaluation of the creative ideas was conducted in two steps. First, to help focus the evaluation, the VE Team weighted the performance criteria defined in the information phase via both the paired comparison and the 100% allocation methods. After much discussion, the VE Team decided by consensus to rank ideas by consensus from 1 (worst) to 10 (best), selecting ideas scoring a 7 or above for development. As a result

of this initial evaluation step, ideas that represent the greatest potential for cost savings and/or value improvement were developed further. Twenty-five ideas were short-listed.

### 3.2.5 Development

VE Team members volunteered to develop selected ideas and document them as VE Proposals. Development consisted of preparing a recommended design with verbal descriptions, sketches, relevant design calculations, cost estimates, benefits, capital cost comparisons, and a descriptive evaluation of the advantages and disadvantages of the proposed recommendation. The original design was also documented with descriptions, sketches, relevant design calculations, and cost estimates for comparison.

Prior to proceeding to scenario development, the VE Team members responsible for development of respective VE Proposals presented the results of their development to the entire VE Team. All disciplines on the VE Team then had an opportunity to comment and improve various aspects of the VE Proposals. This “reality check” helped the VE Team fully understand the VE Proposals before deciding which ones to package together into scenarios.

### 3.2.6 Scenario Development

In this phase, the VE Team determined which of the VE Proposals fit together best into scenarios that could be presented as recommended complete design solutions for the project. A total of three scenarios were developed. As part of scenario development, a capital cost was generated from the compilation of VE Proposals for each scenario. The scenarios were then evaluated against the base case design using the weighted performance criteria and a subjective consensus based scoring system in an evaluation matrix. The Scenario Evaluation Matrix is shown in Table 1. The VE Team modified the evaluation of performance measures to make it easier to understand by using a scale that ranged from poor to excellent, rather than a technically based complex mathematical approach. This enabled all participants including RRIB to fully understand the evaluation process. For the base case and each scenario, the VE Team was asked how well that solution performed for specific performance criteria.

### 3.2.7 Presentation

At the end of the workshop, a presentation was made to the VE Team. The presentation focused on the scenarios evaluated by the VE Team and several other specific VE Proposals and design suggestions recommended by the VE Team. The recommendations and rationale that went into their development and a summary of key cost impacts were presented and discussed. A lively question and answer session followed. Although no firm recommendations were made due to the conceptual stage of the project, the general consensus reached by the VE Team on many of the project issues will greatly benefit the project going forward.

### 3.3 Post-Workshop

The post-workshop efforts included the following:

- Preparing a draft VE Study. The study documents the efforts of the overall VE Team in the workshop to obtain the best value from the monies to be expended.
- Presenting the results of the VE Study to MTO Senior Management.
- RRIB presenting the results of the VE Study to their Council.
- Distributing the final VE Study to the VE Team.
- MTO meeting with RRIB.
- Finalizing the limits of MTO surplus land that will be transferred to RRIB.

## 4. Conclusion

The VE process resulted in a collaborative effort with RRIB that recommended a scenario comprised of a diamond interchange east of the existing Highway 11/17 intersection as shown in Figure 4. The recommended scenario not only scored equal to or better than the original 1996 preliminary design and the other considered scenarios in all performance criteria, but also had the lowest estimated capital cost and resulted in 40% more MTO surplus developable land than the previous design. The recommended design avoided the relocation of the existing highway patrol yard, enhancing the sustainability of the solution. The recommendation also included a local re-alignment of Highway 11 to create a more context sensitive design, which would help to mitigate RRIB's concerns about high speed traffic passing through their community. Constructability was also enhanced by shifting the interchange away from the existing intersection, simplifying traffic management during construction and improving worker safety. With an estimated cost of $26.8 million, the recommended solution offers a $14.3 million (35%) savings over the original design.

This VE process demonstrated the benefits of including external stakeholders, such as First Nations, as full time participants in the VE process to address unique stakeholder issues. This collaboration helps build consensus by allowing stakeholders with limited technical expertise to present their concerns directly to the VE Team, participate in the Function Analysis, contribute to the Creative and Evaluation phases and witness that their ideas are given serious consideration. At the same time, stakeholder participants gain an appreciation for the engineering standards and constraints that impact the feasibility of various ideas. Most importantly, participants gain an appreciation that a fair and transparent evaluation is used in selecting the preferred alternative.

The VE study expedited decision making and helped all parties understand different perspectives from the technical constraints of highway design to local RRIB community aspirations. The VE study selected the best value interchange configuration that would meet the needs of highway travellers and the RRIB.

## Reference

[1] Ontario Ministry of Transportation, MMM Group Limited, Faithful+Gould, McCormick Rankin Corporation, “Value Engineering Study, Intersection of Highway 11 and Highway 17 – Lot 14, Nipigon, Ontario, Final Report”, November 2008

Table 1: Scenario Evaluation Matrix

| SCENARIO EVALUATION PHASE | EVALUATION MATRIX | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HOW WELL DOES EACH SCENARIO SATISFY THE VARIOUS PERFORMANCE CRITERIA? INDICATE BY ENTERING THE WEIGHT (5,4,3,2,1) IN THE APPROPRIATE BOX IN PLACE OF E, VG, G, F, OR P, RESPECTIVELY. | PERFORMANCE CRITERIA | PATROL YARD LOCATION | COMMUNITY DEVELOPMENT OPPORTUNITIES | TRAFFIC OPERATIONS AND SAFETY | SUSTAINABILITY | | | TOTAL PERFORMANCE SCORE | TOTAL CAPITAL COST ($M) | PERFORMANCE = P / C . COST |
| SCENARIOS | WEIGHT → | ASSIGNED WEIGHTS (%) | | | | | | TOTAL 100% | | |
| | | 14 | 28 | 45 | 14 | | | | | |
| BASE CASE | 5 | E | E | E | E | E | E | | | |
| | 4 | VG | VG | VG | VG | VG | VG | | | |
| | 3 | G | G | G | G | G | G | | | |
| | 2 | 2 | F | F | 2 | F | F | | | |
| | 1 | P | 1 | 1 | P | P | P | | | |
| | SUBTOT. | 28 | 28 | 45 | 28 | 0 | 0 | 129 | $41.10 | 3.14 |
| SCENARIO 1: Improvements to Base Case | 5 | E | E | E | E | E | E | | | |
| | 4 | VG | VG | VG | VG | VG | VG | | | |
| | 3 | G | G | G | 3 | G | G | | | |
| | 2 | 2 | F | 2 | F | F | F | | | |
| | 1 | P | 1 | P | P | P | P | | | |
| | SUBTOT. | 28 | 28 | 90 | 42 | 0 | 0 | 188 | $38.60 | 4.87 |
| SCENARIO 2: Diamond Interchange at Hwy 11 East of Existing Patrol Yard | 5 | 5 | E | E | E | E | E | | | |
| | 4 | VG | 4 | 4 | 4 | VG | VG | | | |
| | 3 | G | G | G | G | G | G | | | |
| | 2 | F | F | F | F | F | F | | | |
| | 1 | P | P | P | P | P | P | | | |
| | SUBTOT. | 70 | 112 | 180 | 56 | 0 | 0 | 418 | $26.80 | 15.60 |
| SCENARIO 3: Diamond Interchange at existing Hwy 11 Location | 5 | 5 | E | E | E | E | E | | | |
| | 4 | VG | VG | VG | 4 | VG | VG | | | |
| | 3 | G | 3 | 3 | G | G | G | | | |
| | 2 | F | F | F | F | F | F | | | |
| | 1 | P | P | P | P | P | P | | | |
| | SUBTOT. | 70 | 84 | 135 | 56 | 0 | 0 | 345 | $30.20 | 11.42 |
| SEEK THE BEST – NOT PERFECTION | | | | | | | | | | |

Figure 1: Site Plan


Figure 2: Base Case (hatched area denotes MTO surplus land)

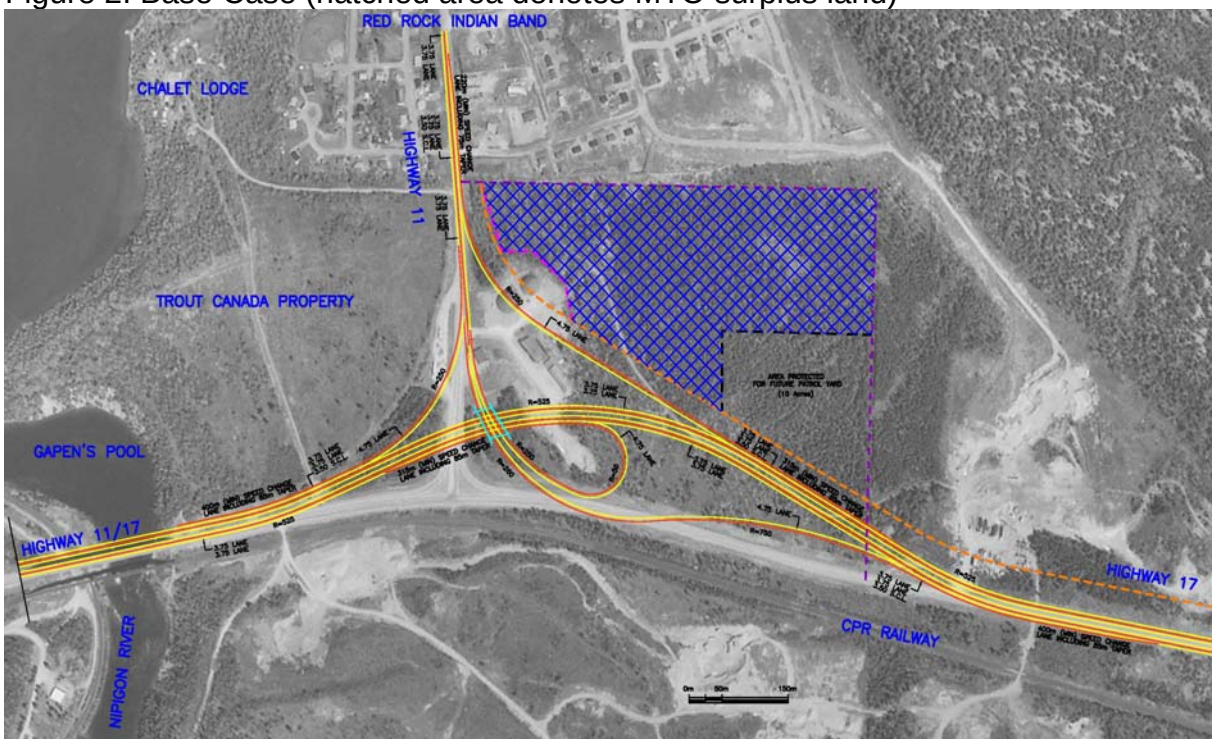

Figure 3: Function Analysis Systems Technique Diagram

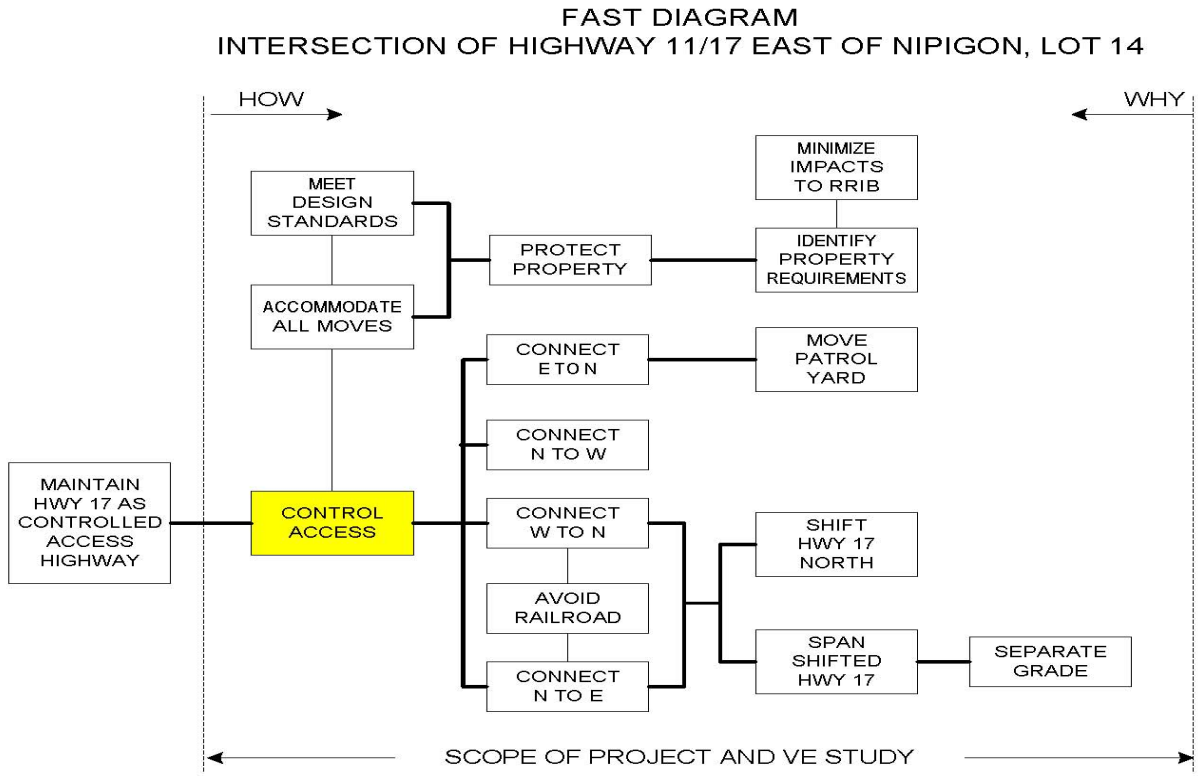


Figure 4: Recommended Scenario: Diamond Interchange East of Existing Highway 11 (hatched area denotes MTO surplus land)