Sustainable Design for the Prince George South Weigh Scale and Four-laning

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ABSTRACT

BC Ministry of Transportation and Infrastructure (BC MoT)'s $30 million Prince George South Weigh Scale and Four-laning project involves approximately 5.0 kilometres of highway realignment and four-laning and a new median Commercial Vehicle Inspection Station (CVIS) near Prince George, British Columbia.

The project is part of the Provincial Weigh2GoBC program (formerly Green Light Transportation System) and the design includes components of environmental, economic, and social sustainability. This paper will describe the details of these components and show how owner initiative and design innovation can produce a highway design project with sustainable benefits to the users and the surrounding environment.

Weigh-in-Motion Technology (WIM)

As they approach the CVIS, trucks are weighed in-motion at high speeds by scales installed in the highway. At the same time, Automatic Vehicle Identification (AVI) devices look for signals from transponders mounted inside truck windshields. WIM systems check the weight and height of the vehicles and AVI systems check records for registration, tax status, and safety status. The driver is signaled via information signs to either report to the station or to bypass the station and continue operating in a steady state mode on the highway. Each bypass results in significant emission reductions, travel time savings, and fuel consumption savings compared to traditional static scale facilities where every truck is required to exit the highway and report to the station.

Geometric Design Optimization

A median CVIS, located between the northbound and southbound lanes of the highway, was selected for this project instead of two side exit inspection facilities. This resulted in a smaller overall footprint on the surrounding land.

Numerous highway alignment options were analyzed through the challenging terrain and soil conditions to minimize construction costs. In addition, the location selected for the station and the vertical alignment design for the highway used the natural grades in the area to aid truck deceleration and acceleration entering and exiting the weigh scale facility, thereby reducing emissions.

Agricultural and Landscape Enhancements

Rather than dispose of surplus excavated material from the project, the material was efficiently used to improve the agricultural capability of two properties located adjacent to the project area. The improvements are expected to enhance the agricultural opportunities and improve the agricultural classification of the site.

Due to the high rate of tree loss in the project area as a result of the Mountain Pine Beetle, an enhanced landscape design was developed that focused on replacing tree vegetation in the project area.

PROJECT OVERVIEW

Highway 97 extends from the Canada–United States border to the British Columbia–Yukon Territories border and is a key north-south transportation corridor in British Columbia (BC) linking the Port of Prince Rupert with the rest of BC and Canada and with the United States (1). In 2006, BC Ministry of Transportation and Infrastructure (BC MoT) started a $200 million project to upgrade the section of Highway 97 linking Cache Creek with Prince George to a four-lane highway (see Figure 1). This upgraded route, which includes the Prince George South Weigh Scale and Four-laning project, will be called the Cariboo Connector (2).

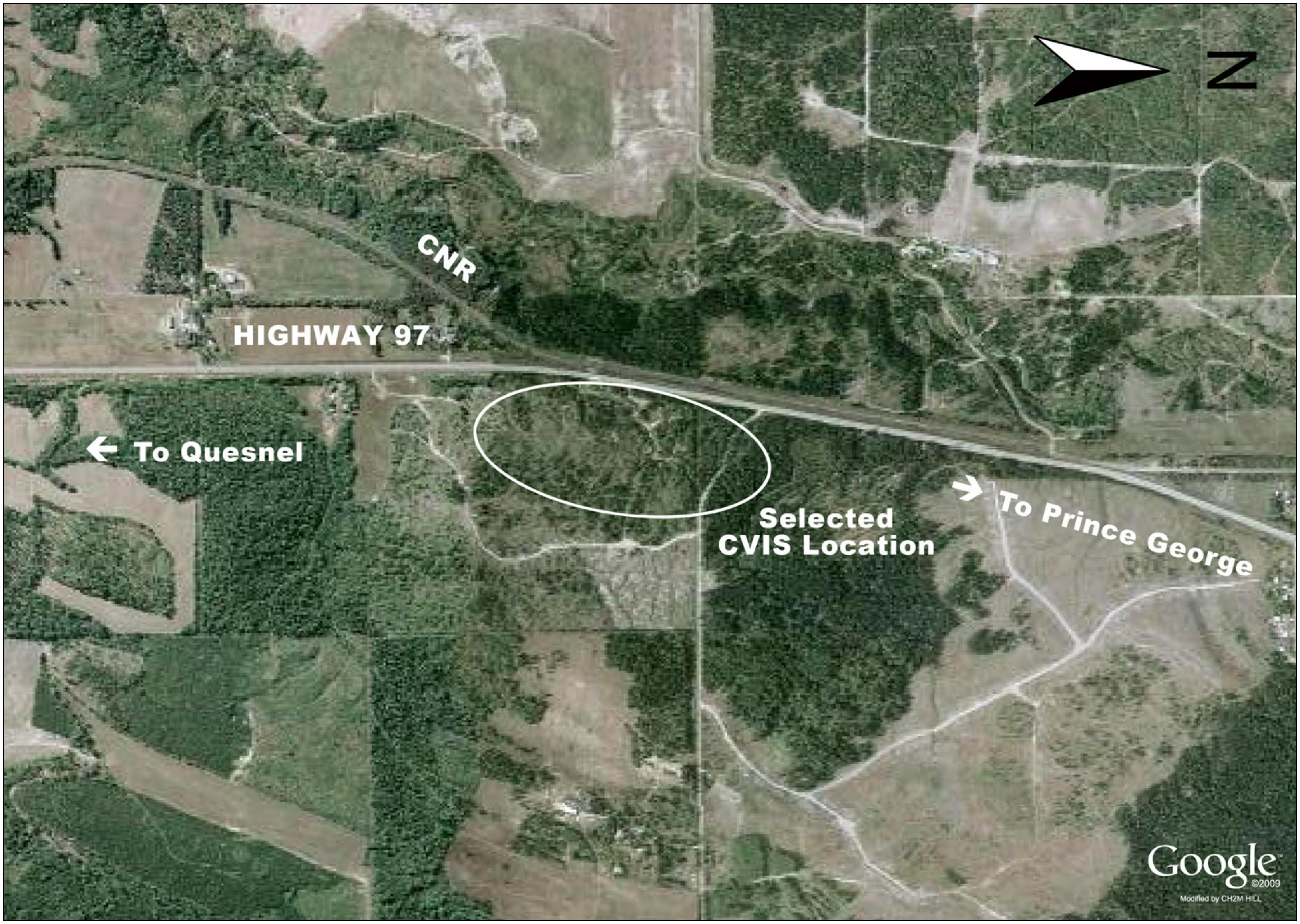
The existing weigh scale in the Prince George, BC area is functionally obsolete. It cannot be modified to accommodate new Weigh-in-Motion (WIM) or Automatic Vehicle Identification (AVI) technology, which allows truck traffic to bypass the scales when specific conditions are met. Furthermore, the existing weigh scale is not located to optimize effectiveness for operators or users. As part of BC's continued commitment to enhancing public services, BC MoT is replacing the existing scale with a new median Commercial Vehicle Inspection Station (CVIS) at a different location and widening approximately 5 kilometres of Highway 97 in the vicinity of the new facility from two lanes to four lanes. The goal of the new CVIS and highway upgrades is to improve efficiency and safety for commercial and recreational traffic (3).

The new CVIS site location is shown in Figures 1 and 2. It is located approximately 25 kilometres south of the city limits of Prince George, in an area dominated by logged and mature forest with agricultural and riparian habitat.

The Prince George South Weigh Scale and Four-laning project was tendered in May 2008 and construction completion is anticipated in the spring of 2010.

FIGURE 1
Project Location Map

FIGURE 2
Selected Location of New CVIS



TECHNICAL CHALLENGES

The main technical challenges on this project involved the location, topography, and geotechnical conditions at the selected CVIS site.

As the majority of the areas outside of the existing Highway 97 right-of-way (ROW) were in the Agricultural Land Reserve (ALR), there was a strong desire to minimize the impacts and minimize the ROW acquisition required for this project. The selected CVIS site is at a location where the existing Highway 97 is constrained by the Canadian National Railway (CNR) to the west, thereby forcing all new construction to be designed on the east side of the highway. The natural ground slopes steeply up on the east side, creating challenges with site and ramp layout, and ultimately resulting in a surplus of excavated materials that required disposal. In addition, an area of high groundwater and generally wet clay and till was identified in the area of the proposed site, creating stability and drainage challenges, as well as resulting in an additional quantity of unsuitable excavated material that also required disposal. With limited opportunities to dispose of the surplus and unsuitable material within the existing Highway 97 ROW, other options and solutions were explored.

The solutions to many of the project challenges included components of environmental, economic, and social sustainability. In addition, the WIM technology adopted for this CVIS is a sustainable transportation solution in itself. The details of these sustainable design elements, and the process that resulted in their implementation, are described in the remainder of this paper.

SUSTAINABLE DESIGN ELEMENTS

To support this paper's claim that the project design includes components of environmental, economic, and social sustainability, the term sustainability must first be defined. There are many definitions of *Sustainability* and *Sustainable Transportation* and it is doubtful that one single generally accepted definition for either term could be identified. However, for the purposes of this paper, the authors define *Sustainability* as:

> Sustainability: Improving the economic and social quality of human life while limiting our impacts on the environment to the carrying capacity of nature.

The design elements described in this paper are considered sustainable because they provide more benefits to economic and social quality of life, and minimize the environmental impacts compared to other viable design solutions.

Geometric Design

One of the first project decisions made by BC MoT was to construct a single median CVIS located between the northbound and southbound lanes of the highway as opposed to two side exit facilities. The smaller overall footprint of the single CVIS minimized the permanent loss of ALR land from future agricultural use and minimized the impact of the project on the natural environment when compared to side exit weigh scales.

Various options were considered for the layout of the CVIS and ramps. The selected option was a "stacked ramp" design with the ramp alignments stacked vertically to follow the natural terrain and situated horizontally as close together as possible. This design provided the opportunity to minimize drainage systems and to locate a required sewage pond in a protected location between ramps, but also had the sustainable benefit of minimizing the impact on surrounding lands (Figure 3).

A final sustainable element of the geometric design was to locate the CVIS on a natural hump in the topography so that the upgrade would aid deceleration for trucks entering the site and the downgrade would aid acceleration for trucks exiting the site (Figure 4). This allowed the designers to shorten the ramp lengths, resulting in sustainable benefits such as reduced impact on the natural environment (reduced footprint and reduced construction materials) and reduced air quality impacts by the users (reduced emissions and gas consumption).

FIGURE 3
Project Layout

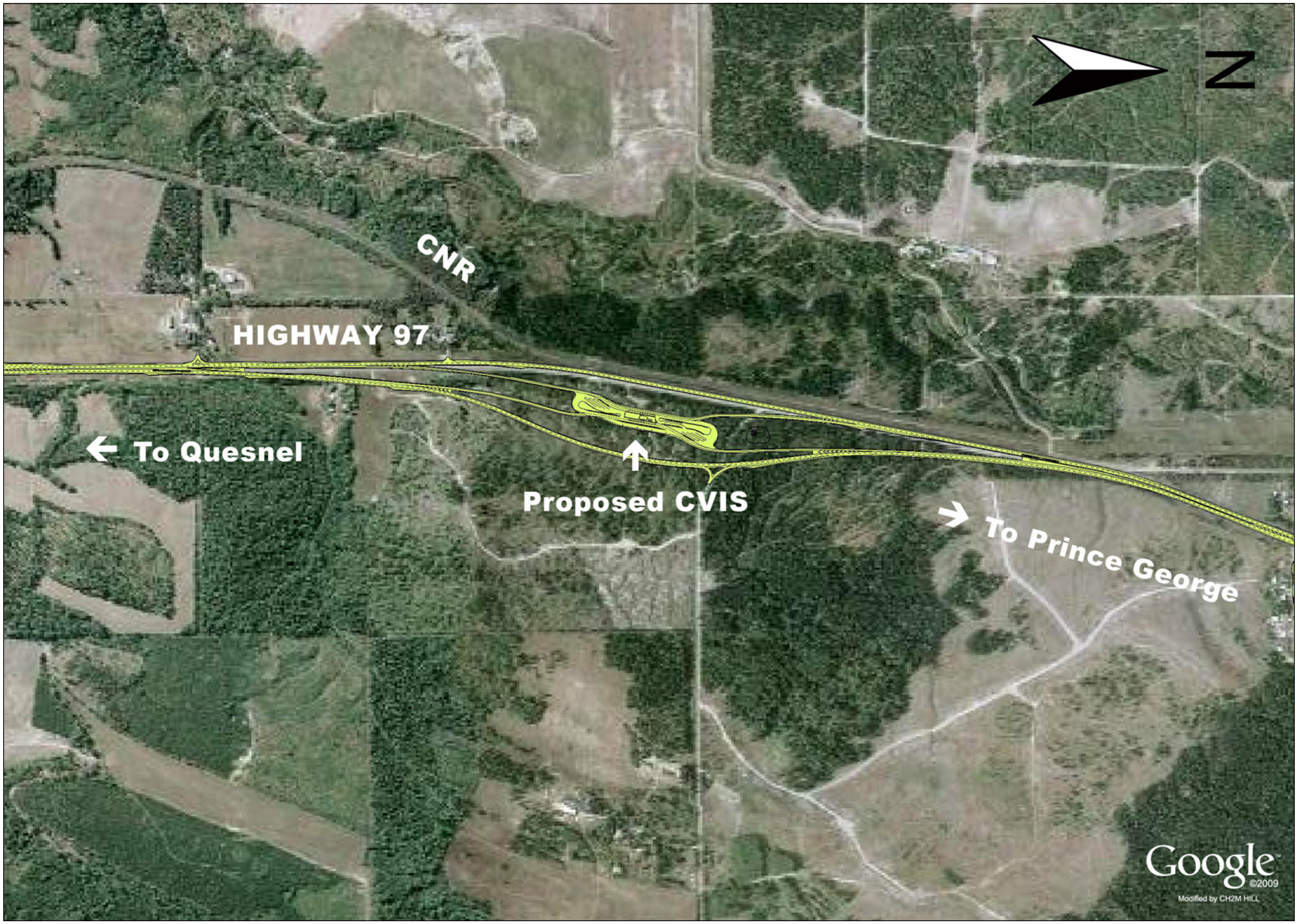
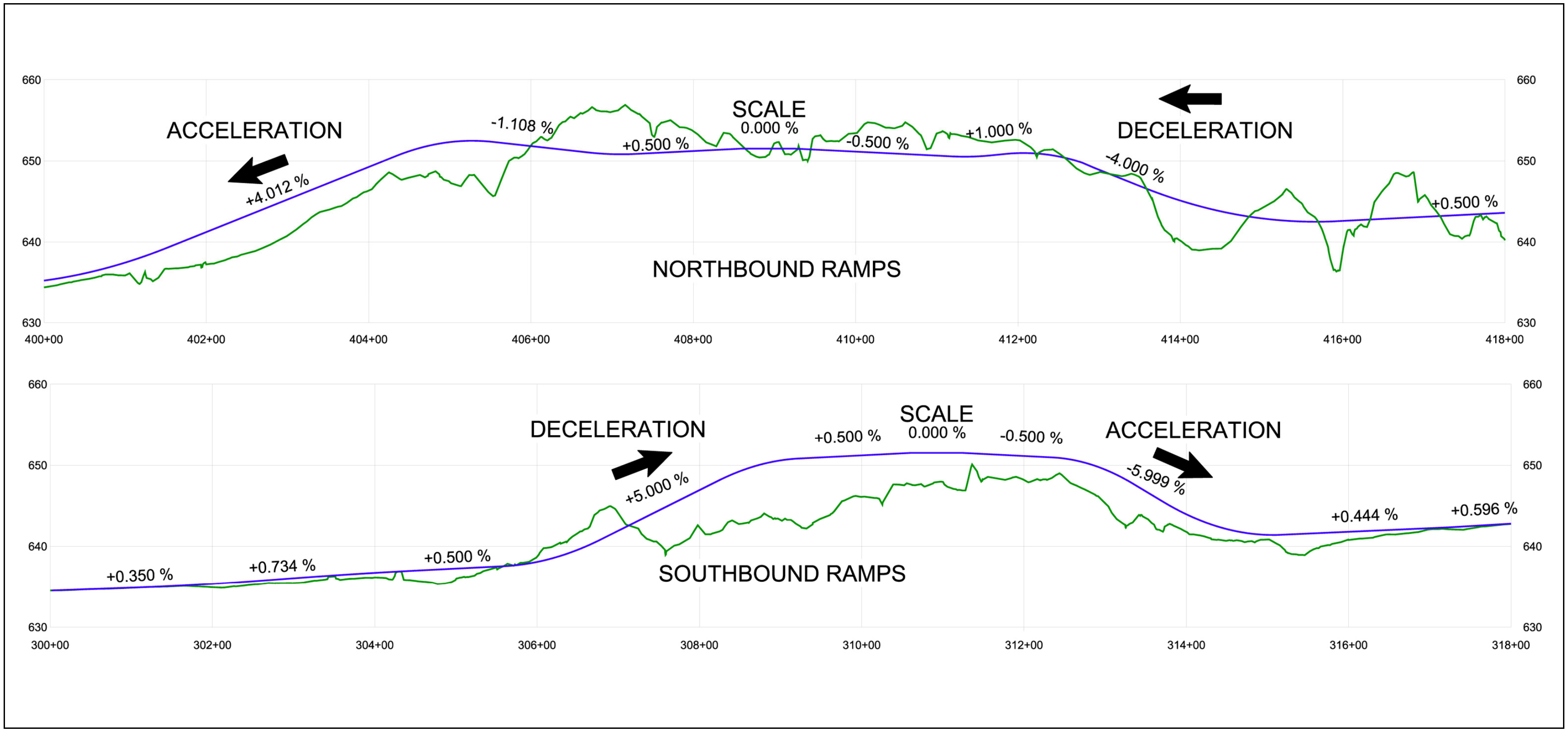


FIGURE 4
Southbound and Northbound Ramp Profiles



Agricultural Land Enhancement

As described above, the site conditions resulted in a significant amount of surplus excavated material. With limited opportunities to dispose of the material within the highway ROW, it was estimated that in excess of 250,000 cubic metres of material would have to be hauled away and disposed of at an offsite location. BC MoT originally planned to make disposal of this surplus material the responsibility of the successful contractor, but with no known, established disposal sites near the project area, BC MoT was concerned that this may not be an optimal, or even viable, solution. The BC MoT project team members responsible for applying to the Agricultural Land Commission (ALC) to have property removed from the ALR suggested that the ALC may support the use of surplus material as fill on ALR lands within the project area if it provided a benefit to the agricultural land use. The idea was appealing to BC MoT on many levels, and they invested considerable time and money to retain a soil reclamation specialist to identify feasible disposal locations, develop a reclamation plan, and prepare a report for the ALC.

The ALR fill location that was ultimately recommended by the soil reclamation specialist and accepted by the ALC is located in a recently logged area in the uplands immediately east of the CVIS (see Figure 5). The fill footprint is approximately semi-circular in shape, and is located on moderate slopes around an elevated pocket of land.

The Fill Placement and Reclamation Plan developed by the soil reclamation specialist indicated that the fill placement would create a large, level field area resulting in the addition of 8 hectares of usable pasture and farmland to the area (4). After final site reclamation and the consolidation of three properties into one, the reclaimed property will be available for redevelopment to become a sizeable working farm. These enhancements are expected to improve the agricultural classification of the land, and the soil reclamation specialist predicted a reclassification from Class 4 to Class 3 land, indicating an increase in the range of crops that can be grown (4, 5).

In summary, the final design for disposing of the surplus and unsuitable excavated material resulted in sustainable economic and social benefits associated with increased agricultural capability. In addition, disposing of the surplus material on the nearby ALR properties had the added sustainable benefit of reduced emissions and gas consumption during construction by reducing the hauling distance that would have been required for offsite disposal.

FIGURE 5
Fill Location on ALR Land

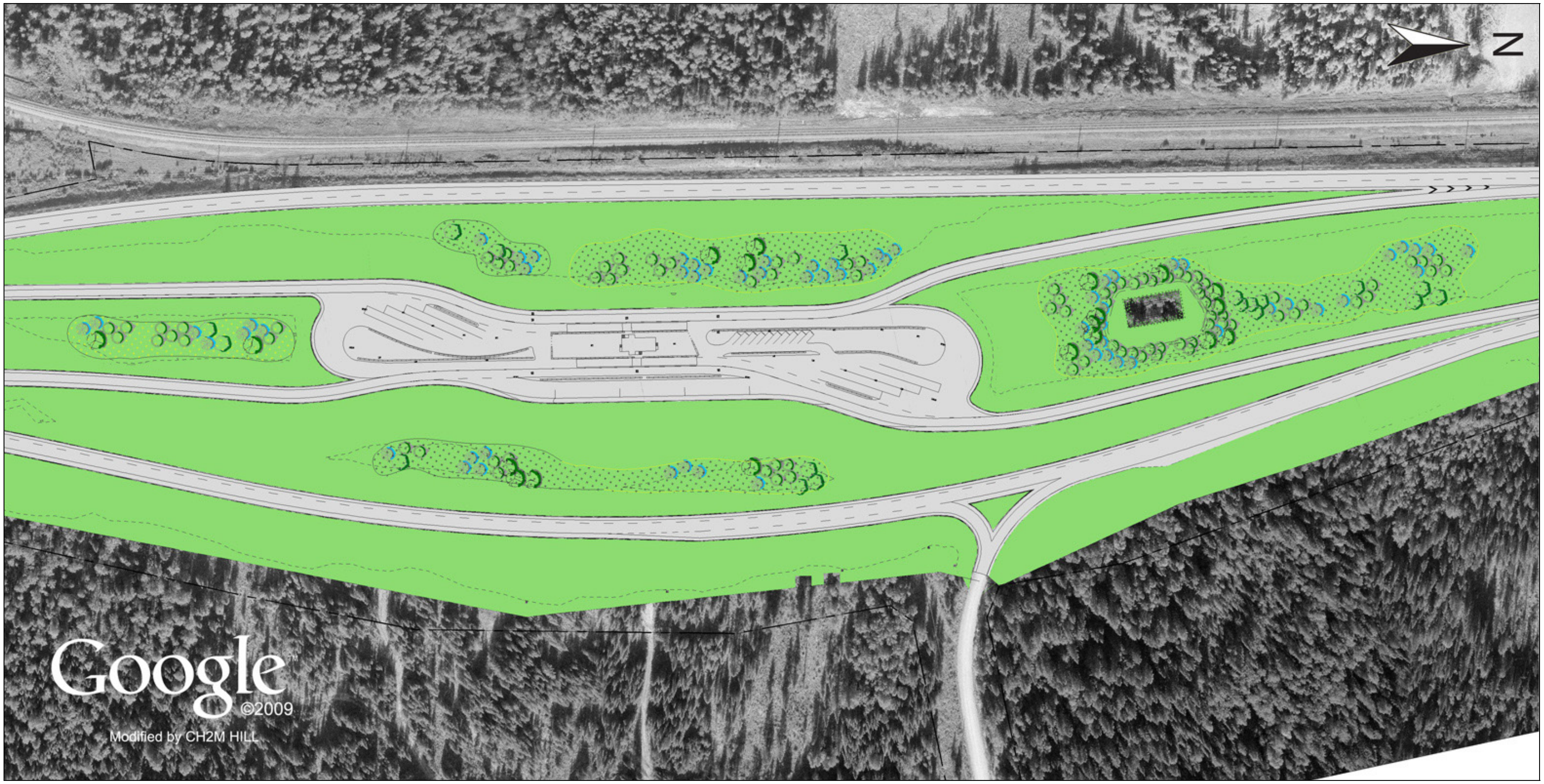
Environmental Considerations

Environmental sustainability was also taken into consideration in the landscape design and the water supply design at the CVIS site.

Due to the high rate of tree loss in the project area as a result of the Mountain Pine Beetle, an enhanced landscape design was developed that focused on replacing tree vegetation in the project area. Although working with a limited landscaping budget, the project will be able to add 150 mature coniferous trees and over 2,300 coniferous seedlings back into the region (Figure 6).

The water supply for the CVIS will be provided by rehabilitating an existing water well located at one of the residential properties acquired for the project. Given that the success rate for new wells in the area is poor, reduced cost risk was the main driver in the decision to rehabilitate rather than drill a new well. However, a well development program has fewer environmental impacts than drilling a new well, and again, the ultimate solution to this project challenge was a sustainable one.

FIGURE 6
Landscape Plan



Weigh-In-Motion Technology

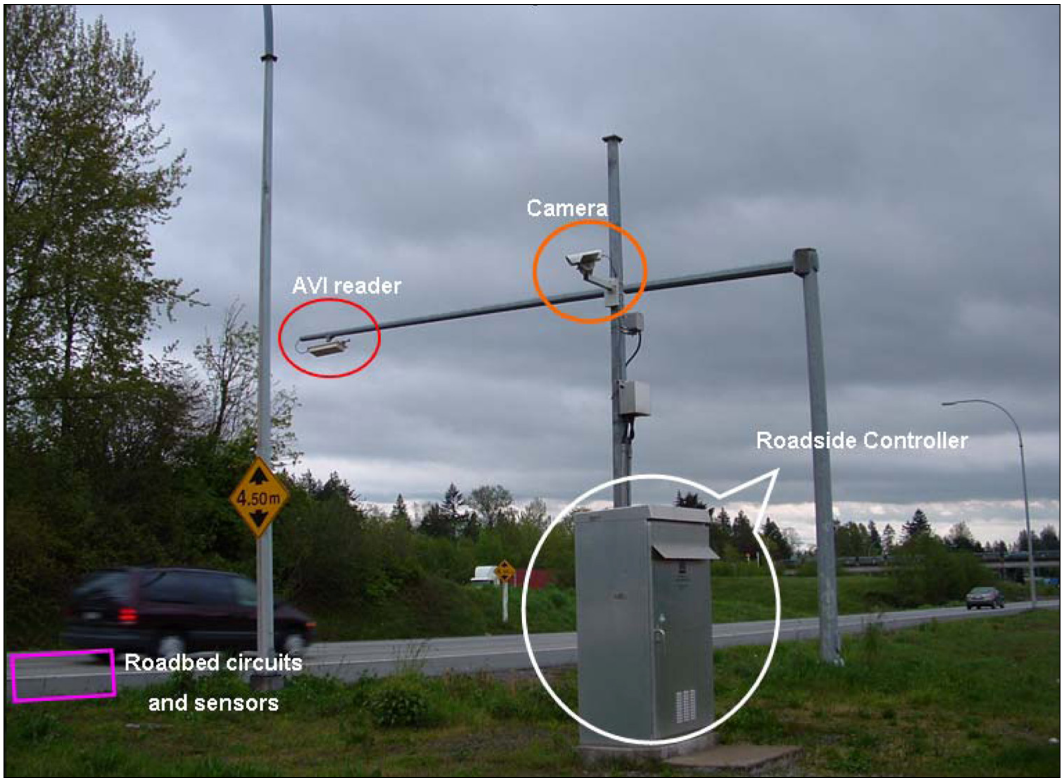
The single-most sustainable element of the Prince George South Weigh Scale and Four-laning project is the installation of Weigh-In-Motion (WIM) technology. This technology allows participating trucks to be weighed while travelling, eliminating the need for qualifying vehicles to enter the CVIS. This leads to improved travel times for trucks and reduces the idling associated with weigh scale visits.

The WIM technology has two main features—scales installed in the highway and automatic vehicle identification (AVI). As trucks approach the CVIS, they are weighed while travelling at high speeds by scales installed in the highway. At the same time, AVI devices look for signals from transponders mounted inside truck windshields. The WIM system checks the weight and height of the vehicles and the AVI system checks records for registration, tax status, and safety status. Drivers are signalled via information signs to either report to the station or to bypass the station and continue uninterrupted on their journey. The officers in the CVIS station are provided with a record of the vehicles pre-cleared on the mainline and are able to adjust the system to select more or fewer vehicles for safety inspections to coincide with the number of personnel on staff.

A complete WIM system includes the following components, some of which are shown in the photograph provided as Figure 7:

- **Advance WIM Location** – The Advance WIM Location includes a weather-proof enclosure to house the system electronics, a camera and illuminator for capturing images during both night and day, overheight detectors, AVI antenna, loops, piezo detectors, and a flush-mounted high speed scale. These are the first locations in the WIM system, and are installed in each direction on the highway in advance of the weigh scale facility.
- **In-Cab Notification (ICN) and Changeable Message Sign (CMS) Locations** – The CMS Locations consist of light-emitting diode (LED) signs to direct trucks to either enter the weigh scale or bypass the weigh scale. The signs are controlled by the WIM system electronics and are triggered by loops in the roadway. Co-located with the signs are AVI antennae at each of the ICN Locations. CMS/ICN Locations are located after the Advance WIM Location in each direction on the mainline in advance of the weigh scale facility.
- **WIM Compliance Stations** – The WIM Compliance Stations are located at the end of each off ramp to the weigh scale and consist of loops in the roadway (ramp and highway) and AVI antenna. WIM Compliance Stations are located at the off ramps in both directions.
- **WIM Main Rack** – The WIM Main Rack is located in the scale building data closet and provides internet access to the CVIS database system, interconnection to the operator terminals, and acts as the hub for the northbound and southbound WIM systems.
- **WIM Fibre Network** – The WIM Fibre Network interconnects each WIM station, various WIM devices, and the WIM Main Rack. The network consists of 18-conductor fibre optic cable installed in conduit along the highway in each direction with capacity for future requirements.

FIGURE 7
WIM Site at Port Mann East (photograph courtesy of BC MoT)



Once construction of the CVIS is complete, it will be added to BC MoT's Weigh2GoBC (formerly known as Green Light Transportation System) program, a network of inspection stations across BC that uses WIM and AVI to identify, weigh, and check credentials of approaching trucks, and to provide automatic bypass at subsequent scales for a 12-hour period for trucks that have passed an initial check (6).

Based on assumptions and industry participation in the Weigh2GoBC program, BC MoT estimates the following projected savings over a 10-year period (6):

- Driver time savings of 387,000 hours
- Fuel savings of 2,395,000 litres
- Greenhouse gas reductions of 6,510,000 kilograms

Oregon Department of Transportation (ODOT) has a similar program called the Green Light Program involving the installation of WIM technology at 21 weigh scale sites. In 2008, ODOT commissioned detailed testing to evaluate the operation and functionality of their system (7). In comparing fuel economy, emissions reduction, and time savings between steady state truck travel and the acceleration and deceleration through weigh scales, Oregon Department of Environmental Quality published the following results (7):

- Fuel economy showed a 57.1 percent improvement for trucks travelling in highway mode in comparison to the acceleration and deceleration pattern typical of a weigh scale interaction.

- Emission measurements showed a significant reduction in each of the pollutants monitored for trucks travelling at highway speeds compared to those travelling through a weigh station. Reductions were 36 percent for carbon dioxide, 36.4 percent for nitrogen oxides, 46.3 percent for hydrocarbons, 48.5 percent for carbon monoxide, and 67.1 percent for particulate matter.
- The average time savings for truck traffic was 1.47 minutes for each weigh scale bypassed.

In summarizing their results, Oregon Department of Environmental Quality indicated that one million bypasses can result in savings of over USD$400,000 in fuel costs; a reduction of 1.5 million miles travelled; and pollution reductions on the order of 875 metric tons of carbon dioxide, 5.5 tons of nitrogen oxides, 0.6 tons of hydrocarbons, 1.6 tons of carbon monoxide, and 0.3 tons of particulate matter (7).

OWNER'S INITIATIVE

The realization of the sustainable design elements for this project is due, in large part, to the initiative of BC MoT. The Province is spending $3 million over three years on the Weigh2GoBC program, with the goal of reducing the need for commercial truck traffic to stop and idle at every weigh scale (8). This demonstrates the Province's commitment to improving the efficiency of commercial truck travel and reducing environmental impacts of this necessary mode of goods movement.

In addition, the mindset of BC MoT staff involved in the project enabled the combined BC MoT and consultant team to implement sustainable solutions in a number of areas. In general, the sustainable solutions resulted from the desire to provide cost-effective solutions to the technical challenges of the project, and were initiated by a variety of team members, including both BC MoT staff and the Design Consultants. BC MoT was receptive to these proposed sustainable solutions and worked with the design team to evaluate and develop the options, and in the case of the agricultural land reclamation, BC MoT retained additional expertise and spent additional time and effort to develop a sustainable solution.

Although most of the sustainable solutions discussed in this paper were not mandated at the beginning of the project (with the exception of the use of WIM technology), the solutions that proved to be most cost-effective and technically-sound were also sustainable, leading to improved economic and social quality of human life while limiting environmental impacts.

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