Summary of activities completed for the development of a binational archive of cross-border wait time data.

U.S. – Canada Border Data Warehouse

Final Report

Whatcom Council of Governments
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Executive summary

As border wait time systems are developed across the U.S. – Canada border, federal, provincial, and state governments, bridge and tunnel operators, and other stakeholders have a shared interest in storing this valuable time series traffic data for multiple uses and applications. In addition to providing performance metrics for the border crossing as a whole, archived data allows for comparative analyses of crossings, evaluations of various technologies deployed to calculate delay, and near-time reporting of conditions to subscribers.

In consultation with the Border Wait Time Working Group, the Whatcom Council of Governments (WCOG) developed an online binational portal to archived wait time data to serve the multiple needs of stakeholder agencies and the serve as a clearinghouse for comparable border data.

The new binational Border Data Warehouse (BDW) is based on previous work WCOG accomplished on a regional border data archive called the Cascade Gateway Border Data Warehouse, located at: www.CascadeGatewayData.com. This regional warehouse stores wait times, volumes, commodity data, weigh-in-motion detector data, and other regionally-specific data sets in formats accessible to the public.

Using a similar XML schema and development platform, WCOG created two new online platforms –the BDW for archiving wait times only from all operating border crossing wait time systems; and a *regional* data warehouse for the Buffalo-Niagara area that, in addition to wait times, stores additional border traffic datasets unique to those crossings' operations systems (loops, toll booths, etc.).

BorderDataWarehouse.com

The primary deliverable of the project is the BDW, an actively compiling database accessed online at www.borderdatawarehouse.com. This website connects users to archived wait times collected from two U.S. – Canada border regions: the Cascade Gateway, and Buffalo-Niagara.

The database and website are scalable to allow for new wait time systems to be added as they are installed. The objective of the site is to provide "one stop shopping" for high-resolution border wait time data that is comparable across all connected crossings.

Buffalo-Niagara region border data archive

Similar to the Cascade Gateway regional archive, the Buffalo-Niagara region-specific warehouse intended to store regional wait time estimates, along with other region-specific data sets. Possible data sets identified at the outset of the project included loop detector volume data from the Ontario Ministry of Transportation (MTO); volume counts from the Niagara Falls Bridge Commission and the Buffalo-Fort Erie Bridge Commission; booth status data from U.S. Customs and Border Protection (CBP) and Canada Border Services Agency (CBSA); NY Department of Transportation volume counter data; and other possible sources.

However these sources were either unequipped for dynamic export or not yet in place and collecting data. Since the only data source currently available in the Buffalo-Niagara region is the Bluetooth system, efforts focused instead on developing the border-wide BDW portal and an *instance* of the Buffalo-Niagara region archive - created but not hosted. It is ready for deployment as a follow-on effort when additional data sources are made accessible.

XML Schema

To enable border-wide compilation and analysis, part of WCOG's scope of work for this project was the development of a standardized XML schema, or structure by which individual regional data feeds will be stored in a common format.

However, this project also took on the task of converting existing data formats to meet the archive's needs. The system can therefore be designed to accept data in almost any available format and apply the schema structure after it's been received in the archive.

But for systems starting from scratch, a detailed XML schema is available to follow so that exports from wait time systems will integrate seamlessly.

Next Steps

WCOG has agreed to maintain the BDW for one calendar year. Beyond that, future maintenance will need to be otherwise provided for. This will be discussed with stakeholder agencies.

Additional ports-of-entry that may come online over the next year should also be incorporated, although there is no identified budget to do so. The project developers have created an estimate for incorporating the data of new ports-of-entry in the final report.

It is hoped that future border wait time installment projects budget a small portion of funds to incorporate the crossing delay data set into the BDW; and that a portion of funds also be used to fund the continued maintenance of this archive.

For the Buffalo-Niagara region, a basic instance of the archive is completed, though not currently hosted. This can be activated upon request of the regional stakeholders and taken over as part of a regional initiative should local data sets be made available and a regional host be identified.

1. Introduction

As wait time systems are developed across the U.S. – Canada border, federal, provincial, and state governments, bridge and tunnel operators, and other stakeholders have a shared interest in storing this valuable time series traffic data for multiple uses and applications. In addition to providing performance metrics for the border crossing as a whole, archived data allows for comparative analyses of crossings, evaluations of various technologies deployed to calculate delay, and for near real-time reporting of conditions to subscribers.

In consultation with the Border Wait Time Working Group (BWT), the Whatcom Council of Governments (WCOG) developed a binational portal of archived wait time data online to serve the multiple needs of stakeholder agencies and the serve as a clearinghouse for comparable border data. The portal is referred to as the U.S. – Canada Border Data Warehouse (BDW).

WCOG also developed an instance of a regional border data warehouse for the Buffalo-Niagara region called the Niagara Region Border Data Warehouse (NRBDW); however since the data displayed on this site is currently the same as what is available on the national portal, only the new *national* warehouse is hosted online at www.borderdatawarehouse.com.

The Cascade Gateway regional border data warehouse

In the Cascade Gateway system of border crossings between the Lower Mainland of British Columbia, Canada, and Whatcom County, Washington, in the U.S.A., there are four ports-of-entry, two of which are less than a mile apart. To expedite crossings for travelers and better spread demand, the WA State Department of Transportation (WSDOT) and B.C. Ministry of Transportation (BCMOT) developed real-time border wait time systems to display estimated delays at the two busiest crossings: Peace Arch/Douglas and Pacific Highway.

These systems displayed wait times but the data were not being stored. In 2005 Transport Canada, with financial partnership from BCMOT and WSDOT, agreed to fund WCOG to develop a regional border data warehouse for the Cascade Gateway.

The archive collects data in five minute increments and makes these data accessible via a website at www.CascadeGatewayData.com. Since its initial development in 2005, the website has expanded to include real-time data from all four Cascade Gateway border crossings and for multiple modes (commercial vehicle, passenger vehicle, NEXUS and general lanes).

In 2007 WCOG received funding from Transport Canada under its Border Information Flow Architecture (BIFA) Pilot Program to use the BIFA template to document associated inter-agency and cross-border data flows as well as to fund significant upgrades to the regional border data warehouse. Improvements were made to the functionality and speed of the web service, as well as the additional of new data sets, including a stream from the U.S. Bureau of Transportation Statistics Transborder Surface Freight database, weigh-in-motion detector data, and an application programming interface (API) to allow other websites and application services to access the data. It provided user-friendly, map-integrated data query tools, dynamic charting, email alert subscription systems, and is Section 508 compliant.

Since 2005 WCOG has developed strong working relationships with partner agencies to monitor the transfer of data to and from the archive and to maintain and enhance system performance.

It was this experience that WCOG used to proceed with the design and implementation of a similar regional system for the Buffalo-Niagara system of crossings, and for a U.S. – Canadian national portal.

Border Wait Time Measurement Program

Under the Security and Prosperity Partnership (SPP) program launched by the leaders of Canada, Mexico, and the United States in 2005, Transport Canada provided funding to support the deployment of Intelligent Transportation Systems (ITS) to measure and distribute border wait time information.

The objectives of this program were to improve mobility and transportation efficiency, productivity, safety, and security for passengers and freight at border crossings; support tourism, trade, and traffic flows on north-south transportation corridors; and to improve the efficiency of border operations.

In consultation with the BWT, WCOG submitted a proposal to develop the BDW as a one-stop shop for all wait time data emerging from installations of real-time border delay measurement systems across the U.S. – Canada border. Overall project goals were to build on the model of the Cascade Gateway Border Data Warehouse by designing and deploying a similar system for the Niagara region border crossings; develop a U.S. – Canada border-wide web portal for these and future regional wait time archives; and to complete the work in a way that advances a standard approach for continued deployment as other border wait time systems are implemented.

Project stakeholders

A first step in the project was to interview regional and national stakeholders and collect needs, interests, and available data sets using a survey. The survey and results are available in **Appendix A: User needs questionnaire technical memo**.

Project stakeholders identified through this process included the following organizations:

Project Advisory Committee	System Managers
U.S. Federal Highway Administration	Ministry of Transportation, Ontario
Transport Canada	NITTEC
U.S. Customs & Border Protection	NY Department of Transportation
Canada Border Services Agency	Buffalo & F Erie Public Bridge Authority Niagara Falls Bridge Commission
Whatcom Council of Governments	Free Ahead, Inc.

Selection of project developer

WCOG developed a request for proposals (RFP) to complete work on both data warehouses. Selection criteria were based on understanding of the project, a methodology and approach that mirrored the requirements identified in the Cascade Gateway warehouse project; a statement regarding long-term maintenance; qualifications and experience of the project team; and cost.

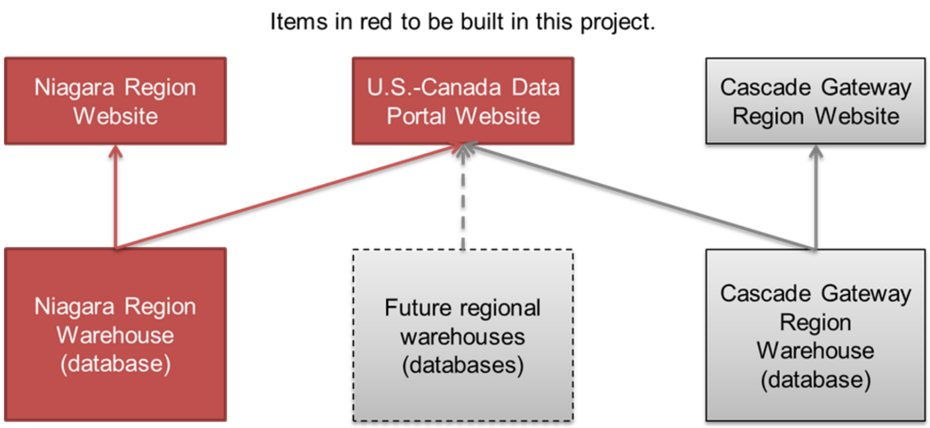
IBI Group was the consulting firm selected and has successfully completed development.

2. Borderdatawarehouse.com

Located at the URL www.borderdatawarehouse.com, the BDW archives wait time estimates for the Niagara and Cascade Gateway region border crossings in increments of five minutes.

System requirements

These system requirements were identified for the development of the NRBDW and the BDW. The original schematic of the project was as illustrated below:



Requirements were first identified from the experiences of developing, operating and maintaining the Cascade Gateway Border Data Warehouse; and from the user feedback survey conducted at the beginning of the project.

The following requirements were used as the basis of the system design and implementation of the final website.

Interoperability needs

1. **The warehouse needs to be developed in compliance with Section 508 of the Rehabilitation Act of 1973 as amended (29 U.S.C. 794d) and in compliance with the international Web Content Accessibility Guidelines (WCAG) for accessibility for all users.**
   1.1. Warehouse developers shall design the website to be U.S.C. Section 508 compliant and run compliancy checks prior to project finalization.
   1.2. Warehouse developers shall design the website to be compliant with World Wide Web Consortium's (W3C) WCAG 2.0 except for the content listed in the Treasury Board of Canada exclusion list (http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=23601&section=text#appB).
   1.3. Warehouse developers shall show administrators how to maintain the website in such a way as to continue to keep all aspects of the site accessible to all users.

2. **The warehouse needs to be developed with templates that make it clearly viewable on a variety of devices including but not limited to computers, smart phones, and tablets.**
3. **The warehouse needs to provide data in a downloadable and exchangeable format usable on multiple platforms.**
4. **The warehouse needs an API interface to allow the data to be used by other websites, agencies, or applications for greater dissemination of data**.
   4.1. The warehouse shall have an application programming interface (API) component to allow data to be shared with other websites.
   4.2. The API shall be designed in such a way as to maintain the security and integrity of the original database.
5. **The warehouse needs to be designed in a way to provide data not only to the Buffalo-Niagara Region Border Data Warehouse website, but to the U.S. – Canada Border Data Warehouse website.**

User functionality needs

6. **The warehouse needs a map view showing crossing locations for users to access port-level data.**
   6.1. The warehouse shall use an online mapping system to display crossings.
   6.2. Crossings shall be available for each direction.
   6.3. Clicking on a crossing icon shall direct a person to a calendar view of that crossing's data.
7. **The warehouse needs a map view showing detector locations.**
   7.1. The warehouse shall use an online mapping system to display devices.
   7.2. The map shall be zoomable to allow end users to select specific devices from the map itself if applicable data is available.
   7.3. The warehouse shall allow users to select multiple devices on the map that will then populate a custom query field if applicable data is available.
8. **The warehouse needs to display data in a clean, easy to understand calendar format.**
   8.1. The warehouse shall separate out data sets using tabs at the top of the page for each data type.
   8.2. The warehouse shall display each data type in a similar manner.
   8.3. The data shall be presented in calendar format.
   8.4. The data shall also be presented in data tables and charts.
   8.5. The data shall be viewable by port-of-entry.
   8.6. The data shall be viewable by direction.
   8.7. If detector-level data are available, they shall be viewable by detector.
   8.8. The warehouse shall be designed in such a way that different border traffic types can be reported separately or in aggregate, by port location, and by direction. These include regular passenger vehicles, NEXUS passenger vehicles, Ready Lane passenger vehicles, regular commercial trucks, FAST program trucks. Flexibility should be maintained to add future traffic types if needed.
   8.9. Data charts shall be printable and downloadable.

8.10. Data charts shall be dynamic and allow for end user customization of scales, timelines, and comparisons.

9. The warehouse needs to display a variety of data sets.

9.1. The data shall be stored in current, actual, and predictive formats where available.

10. The warehouse needs to provide all data components in a downloadable format.

10.1. Warehouse data shall be downloadable in a .CSV format.

11. The warehouse needs to display reports that can be defined from custom queries by the administrator.

11.1. Reports shall be viewable on screen or downloadable as .CSV files.

11.2. The Reports section of the website shall provide a list of compiled reports for viewing.

11.3. The reports shall be designed in such a way that they are kept current (i.e. new data is included in the report query).

12. The warehouse needs a custom query tool that allows for multiple aggregations as defined by the end user.

12.1. The query tool shall result in multiple output types including data table, chart, and downloadable .CSV file.

12.2. The query tool shall allow users to select date ranges, days of the week, and hour ranges.

12.3. The query tool shall allow users to group, summarize, and generate descriptive statistics for data by month, day of week, day, am/pm, hourly, by five minute increment.

12.4. The query tool shall allow users to group by regular passenger vehicles, NEXUS passenger vehicles, Ready Lane passenger vehicles (if data is available), regular commercial trucks, FAST program trucks.

12.5. The query tool shall allow users to query multiple devices (if applicable) or crossings at a time.

12.6. The query tool shall allow users to query multiple crossing locations at a time.

12.7. The query tool shall report times on a 24-hour clock (00:00 – 23:59) in the local time zone of the crossing location.

12.8. The query tool shall allow users to aggregate data by various measures including average, max, min, and sum values.

12.9. The query tool shall allow users to view multiple measures of data (if applicable) in one query (i.e. volume, wait times, etc.).

12.10. Query tool results shall be available as a unique URL so the custom query may be emailed or shared with other partners.

13. The warehouse needs a help system that provides information on how to use each page.

13.1. Both websites shall have help links on each page that links to a pop-up/section of the page with useful instructions.

13.2. Help resources shall include short explanations of how each set of archived data is generated and what it represents.

14. **The warehouse needs a color-coded flagging system (i.e. green for good, yellow for caution, red for danger) for each day or month of the day/month view that has a data feed that may be erroneous or incomplete.**
    14.1. The warehouse shall display color coded symbols on each calendar or day view relating to the percentage of data packets received.
    14.2. The website shall display warnings to users who run queries using data flagged as red.
15. **The warehouse needs an automated email subscription service for reporting delay that users may subscribe/unsubscribe to and define the threshold of delay and crossings they are interested in.**
    15.1. The warehouse shall allow users to sign up for automated email reports of delay.
    15.2. Users shall be able to define the ports, directions, and traffic types they are interested in.
    15.3. Users shall be able to define the threshold of delay they are interested in.
    15.4. Users shall be able to unsubscribe from these reports at any time.
    15.5. Users should be able to define how often they want e-mail alerts (ex. daily, hourly, when defined threshold is met, etc.)
16. **The warehouse needs an automated email subscription service for delivering static reports to users that subscribe/unsubscribe to the service.**

Administrative functionality needs

17. **The warehouse should be updated at least every hour and as close to the source system frequency as is practical.**
18. **The warehouse needs to allow administrators to save a custom query as a static report that can be dated for an end date in the future.**
    18.1. Administrators shall be able to design and save any custom query as a report.
    18.2. Administrators shall be able to delete or rename any report.
    18.3. Administrators shall be able to organize the list of reports.
19. **The warehouse help sections need to be designed for administrators to edit.**
    19.1. Administrators shall be able to add, edit, and delete content for each help section.
    19.2. Administrators shall be able to use HTML code within the help section to format text.
20. **The warehouse needs an automated delay subscription service that allows administrators to manage subscriptions for individuals.**
    20.1. The warehouse delay subscription service shall allow administrators to see the email addresses and subscription details of all those subscribed to the email alert system.
    20.2. The warehouse delay subscription service shall allow administrators to sign individuals up by entering an email address, port(s) and direction(s) of interest, and threshold of delay.
    20.3. The warehouse delay subscription service shall allow administrators to delete subscriptions.
21. **The warehouse needs an automated email subscription service for delivering static reports to users that subscribe/unsubscribe to the service.**

21.1. The warehouse report subscription service shall allow administrators to see the email addresses and subscription reports of all those subscribed.

21.2. The warehouse report subscription service shall allow administrators to sign individuals up by entering an email address, frequency of reporting updates, and the name of the static report(s).

21.3. The warehouse report subscription service shall allow administrators to delete subscriptions.

21.4. E-mail subscription services shall generate an alert to subscribers when subscription-based alerts or reports are removed.

22. The warehouse needs to alert administrators when new hardware is detected by the system.

22.1. The warehouse shall send an email to administrators when new hardware is detected.

22.2. The warehouse shall alert administrators when devices have been detected that are not mapped.

23. The warehouse needs to allow administrators to enter or alter geo-coded mapped information for crossings and devices.

23.1. The warehouse shall allow administrators to edit the geo-location of each device and automatically display this detector on the map.

23.2. The warehouse shall allow administrators to edit crossing locators on the map.

24. The warehouse needs to be designed in a way that alerts administrators of the health of the warehouse.

24.1. The warehouse shall send daily reports to registered administrators showing a health snapshot of the data.

24.2. The warehouse shall send reports to administrators when data connections are broken.

24.3. The warehouse shall alert administrators when devices are not mapped to the system.

24.4. When applicable, a border crossing that does not have one or more volume detectors selected shall alert the administrator.

24.5. The warehouse shall alert administrators if the storage of the server reaches critical capacity.

Growth and maintenance management needs

25. The warehouse needs to be designed in a way that makes it simple to modify and maintain.

25.1. The warehouse shall allow administrators to add or edit data feeds into the system.

26. The warehouse needs to be built for future expansion and increased archiving requirements.

26.1. The warehouse shall be designed in such a way that additional storage capacity can be added without redesigning the warehouse structure.

26.2. The warehouse shall be designed to store differing types of data and different file types.

26.3. The warehouse shall be designed in such a way that allows for expanding data types across the tabbed menu bar.

26.4. The custom query shall allow users to query all the different data types available.

27. **The warehouse needs to be accessible and queriable quickly and efficiently.**

27.1. There shall be no more than a five second delay for each page load on the website.

27.2. There shall be no longer than a 10 second delay for downloading large custom queries.

27.3. Queries that are too large to display will result in instructions to the user to download the file.

27.4. The warehouse shall be stored on a server with enough capacity to house rapidly increasing volumes of data.

27.5. The warehouse shall be stored on a server designed in such a way that website functionality is separated from data storage to facilitate faster response times.

27.6. Warehouse data backups shall be stored in a location that will not impact the speed or functionality of the website.

28. **The warehouse needs to be designed to automatically detect new data sources in the system and store that new data appropriately.**

28.1. The warehouse shall use the XML schema to automatically store new hardware and data feeds.

28.2. The warehouse shall send the administrator an alert when new data feeds are detected.

28.3. The warehouse shall provide steps for administrators to customize information for each new port-of-entry or detector.

29. **Documentation needs to be developed in such a way that the functionality and maintenance of the warehouse is clear for future developers.**

29.1. Warehouse developers shall develop documentation on how the warehouse has been built; hardware specifications; programming knowledge needed; and how and where data are stored.

29.2. Warehouse developers shall prepare documentation on how the warehouse should be maintained.

29.3. Warehouse developers shall prepare documentation on how administrators can make changes to the warehouse.

30. **Database and website formats need to be in an industry-standard programming language that allows for multiple developers to easily understand and address future issues.**

30.1. The warehouse shall be designed using a common programming language and on a common server operating system.

30.2. Any customized components of the warehouse shall be described in detail in documentation with instructions on how that component ties into the full warehouse.

31. **A security audit of the warehouse needs to be completed at the conclusion of the project to alert administrators of any possible risks to the database.**

31.1. No personal identifiable information (PII), including MAC addresses, shall be stored in the database.

Additional systems engineering documents

All systems engineering documentation for this project are available in the appendices including the following:

- **Appendix B: Concept of operations**
- **Appendix C: System validation plan**
- **Appendix D: Project architecture**

Design of the database

IBI Group developed the database as a SQL Server and used the .NET platform to build the interface. A separate instance of the server was built on the Amazon Web Service where the Cascade Gateway database is stored. Initially the design considered having a singular instance that all regional and national databases would pull from; however upon looking at the unique characteristics of regional archives compared to those of a border-wide database it was decided that two separate instances would function more seamlessly.

Details about the programming and development of the database are available in **Appendix E: System design documentation**.

Website features

As laid out in the system requirements, the website offers the following features for end users:

- **Data displayed by crossing**: Users can zoom in and out on a dynamic map or use a drop-down menu to select Cascade Gateway or Buffalo-Niagara region crossings by direction. Data are then displayed in graph and chart form.
- **Data available in multiple metrics**: Wait time estimates are available for passenger and commercial vehicles as made available by the hardware at each particular crossing. Additionally, crossings in the Niagara region also collect wait times in three separate metrics: actual delay (the delay experienced by the traveler), current delay (the delay estimated for the next arriving traveler), and predicted delay (a currently non-standardized estimate of wait time at a future point).
- **Data downloadable**: All data are available for export as a CSV file for additional querying using a spreadsheet program.
- **Query functionality**: A detailed query tool allows users to choose one or more crossing and compare values at specified summary levels. This allows for convenient port-by-port or time series comparisons.
- **API**: The application programming interface allows developers of smart phone and web applications and other websites to run queries based on easy to understand URL string queries. This allows the data to be used openly by any public or private agency.

- **Reports**: Queries that are frequently run or requested can be saved as reports, allowing users to easily find answers to common questions (i.e. the average wait going into Canada on weekends).
- **Subscriptions**: Users can sign up to receive email notifications when delays at one or more crossing reach a specified threshold. The user can also define how often they receive those emails – daily or for a specific period of time during the day.[1]

Next steps

Now that the national archive is available and includes two regions (seven ports-of-entry), it is hoped that the site will expand to incorporate data from other border wait time systems as they come online.

To incorporate additional sites into the archive, the web developers have established an estimate cost per site to incorporate the data feeds in whatever format they are made available. **See Appendix F: Cost estimates for additional crossings**.

[1] It is important to note that, unlike the Cascade Gateway Border Data Warehouse, data are uploaded to the BDW at a delay. Therefore the subscription service does not provide real-time updates in terms of border delay.

3. Niagara region border data warehouse

As part of the original scope of work, WCOG was also to develop the NRBDW, a regional warehouse that would house not only the data coming from the Bluetooth system installed through the BWT, but other data specific to the region.

BWT's Bluetooth system

The BWT Working Group advanced a pilot project to install Bluetooth readers along two bridges, in both directions, in the Niagara region to test the efficacy of the technology in reporting reliable wait time estimates to the traveling public.

Data coming from the system are shared with inspection agencies, bridge commissions, and with the project developers, Free Ahead Inc.

This data feed was the first to be incorporated into the NRBDW.

Additional regional data

Speaking with stakeholders, WCOG identified numerous existing and potential additional data sources in the region that could be archived for the benefit of regional stakeholders. See **Appendix G: Niagara border wait time project schematic**.

Possible data sets considered for the regional warehouse included the following:

- **Ministry of Ontario loop detectors**: MTO expressed interest in expanding on the Bluetooth system installed at the Buffalo/Niagara region crossings with loop detectors that would provide volumes, queue lengths and speeds. However this technology was not added in time to be included in this project.
- **U.S. Customs & Border Protection booth status data**: WCOG has been pursuing efforts to develop a link to real-time booth status information for the ports-of-entry in the Cascade Gateway in order to improve the accuracy of southbound border wait times and to provide additional metrics for planning and analysis. This initial interest has become a more generalized initiative within CBP to avail booth status data for all border crossings. It was hoped this expansion would include the Niagara region and real-time data sets from the primary inspection lanes would provide processing rates and volumes to compliment the installed Bluetooth system, but the system modifications needed to make these data accessible to outside sources are underway currently at CBP headquarters and the data are not yet available.
- **NY Department of Transportation corridor travel times**: The New York Department of Transportation collects corridor segment travel times in the region via Transcom toll tags. A portion of the region where these data are collected includes the

border crossings. The data should be explored when other data, more operationally connected to the border crossings, is available for dynamic archiving.

- **Bridge commission vehicle counts**: Both the Buffalo/Fort Erie Bridge Commission and the Niagara Falls Bridge Commission were asked if they could provide vehicle counts from their internal systems to be included in the regional database. While both bridge authorities acknowledged the existence of these data interest in archiving it was mixed. Where there was such interest, mechanisms for automated file transfers do not yet exist.
- **Manual data overrides**: The Niagara Falls Bridge Commission retained an option to manually change displayed wait times for their facilities when they observe the Bluetooth system generating inaccurate estimates. WCOG asked whether manual overrides could be saved in the archive alongside the system estimates but there was little interest and it was dropped.
- **NITTEC**: The Niagara International Transportation Technology Coalition (NITTEC) is a regional coalition of agencies focused on providing real-time traffic and transportation related information for the border crossings in the Niagara region. NITTEC appears to be suited as an ideal manager of the completed regional warehouse, given its multi-agency makeup, its traffic operations center, and mission to improve mobility through sharing and coordinated management of operations. NITTEC also maintains the region's ITS architecture. The project was discussed with NITTEC at the outset.

Warehouse completion

Given that none of the identified additional data sets listed above became available or accessible over the duration of this project, the only data ready for the regional archive was the Bluetooth system data - which was also feeding directly into the BDW.

Rather than displaying the same data, it was determined that, at this time, the regional warehouse would be put on hold until additional, region-specific datasets were ready to include.

An instance of the NRBDW has been developed by IBI Group and stored on the project server. However no URL has been purchased for it, and the site is not currently hosted for sharing with the public.

The NRBDW is ready to incorporate additional data and go live when project partners and a host are identified and funding made available to take the warehouse to the next step.

4. A standardized XML schema

To enable border-wide compilation and analysis, part of WCOG's scope of work for this project was the development of a standardized XML schema, or structure by which individual regional data feeds will be stored in a common format.

However, this project also took on the task of converting existing data formats to meet the archive's needs. The system can therefore be designed to accept data in almost any available format and apply the schema structure after it's been received in the archive.

For systems starting from scratch, a detailed XML schema is available in **Appendix H: Border Data Warehouse XML schema** to best structure new data systems in a way that would integrate seamlessly with data on a binational level.

Initial impetus for improvements

The original XML schema used for the Cascade Gateway Border Data Warehouse was based on the Institute of Transportation Engineers' Traffic Management Data Dictionary (TMDD) Standards[2] but altered slightly to fit the specific needs of the project. It defined how units would be translated into the database, what fields would be called, and how each data collection device or crossing would be identified.

However problems were identified with the original schema:

- The system only understood data parsed into specific five minute time increments (i.e. 12:00 or 12:05) and so data coming in with a different timestamp would be rolled into another increment level inappropriately (i.e. 12:07).
- The schema itself was repetitive. Every detector was listed explaining what road it was on, what direction, and what crossing, rather than having all this information available in a single section. It also didn't divide the information along an intuitive hierarchy, i.e. organized by crossing, then lane, then booth, etc.
- Another issue was discovered when the system starting collecting weigh-in-motion detector data, because these data were per vehicle, not per time period.
- The system was designed specifically for Cascade Gateway's needs and loop detector hardware. However to be able to take in other forms of data including feeds from inspection agencies, Bluetooth readers, and other technologies, the schema needed to change.

First steps

A draft version of a modified schema was developed to define every element at the beginning with a border inventory that clarified the systems being described and related each detector to a lane,

[2] http://www.ite.org/standards/tmdd/

highway, or crossing once. It also addressed the issues above, specifically looking to reduce challenges for reluctant data partners and make it easier for them to share data. A copy of the initial draft schema is available in **Appendix I: Border Data Warehouse XML schema**.

A strategy change

Upon subsequent analyses, however, the project team concluded that the level of customization required by data providers to match exports to this schema was impractical. It was decided therefore to return to the basic standards and incorporate only a small number of custom fields. This allows for the vast majority of data providers to have their data almost completely accessible by the system.

The final XML schema developed incorporates most of its elements from the standards established by the TMDD with minimal changes. This schema will be made available to any agency or organization interested, and will also be retroactively applied to the Cascade Gateway Border Data Warehouse.

Future border wait time systems may be designed to export their data in this schema, however the national BDW has been designed in such a way as to take the burden of customization away from the data provider and put it on the archive management. In other words, usage of this schema in the future is recommended, but not necessary to have data included in the archive.

5. Next steps and recommendations

The development of the BDW and NRBDW was completed in March, 2014. WCOG has agreed to maintain the BDW in its current format for a period of one year following the completion of this project.

Future enhancements and ongoing maintenance

At the time of this report no future enhancements have been identified. However as the website is used and more data is stored in the archive it is that additional features, functions and fixes will be required for the ongoing performance of the website.

Over the course of administering the Cascade Gateway Border Data Warehouse, several small changes have resulted it server outages. BCMOT moved its data to a new location and didn't inform archive managers. WSDOT changed the naming scheme applied to its loop detectors and data were erroneously being assigned to the wrong lanes. Server logs backed up and impacted performance. Updates to SQL server software were required to maintain speed and overall functionality.

In addition, as more users took advantage of the website, errors were discovered, either in the programming or in the data itself, which required follow-up on the part of the site administrators.

However beyond March 2015 there is no identified funding or agreement to maintain the BDW.

For the BDW to continue with the ability to include future wait time system installations, a solution needs to be identified for the ongoing database and site maintenance.

Project funding partners have specified that paying for maintenance of a website beyond the original project end date is not possible, nor is it even allowed to describe something as "maintenance" during the life of the project. This becomes an issue when sustaining a service like a website that needs small but continuous fixes over the course of its life.

As larger investments are made in the ITS infrastructures at border crossings, providing for the ongoing storage and access of data produced by these systems should be acknowledged as a discrete need. The cost-benefit ratio of archived data for the purposes of project monitoring, performance measurements, and safety evaluations is very high; historical data cannot be recreated once it is lost.

However the funding options for a program such as this, which serves a large geographic region and multiple stakeholders, may easily slip through the cracks. As the binational, multi-agency effort to deploy border wait time systems continues, federal government proponents should seek to establish ongoing programmatic funding for operation and maintenance of the BDW and related data connections. This would serve the mutual interests in performance metrics established in the Beyond the Border Action Plan.

The future of the Niagara region border data warehouse

To advance the NRBDW, stakeholders in the region will need to identify what additional data sets are a priority for archiving and take steps to make that data available to developers for the website. With identified data sets and funding the site can go live.

Local interest in the archive and its maintenance is also crucial for the longevity of the project. Regional organizations like NITTEC would be best suited to host an archive of this nature. If a regional entity expresses interest, WCOG will be able to hand off all relevant data files, the database, and other materials.

Appendix A: User needs questionnaire technical memo

January 31, 2013

1. Introduction

This memo summarizes a questionnaire that was circulated as part of the U.S.--Canada Border Data Warehouse.

The user needs questionnaire was made available to representatives of agencies who are understood to be primary future users of a web based archive of cross-border wait time and traffic data in the Niagara region. The questionnaire was developed and distributed using Survey Monkey -- http://www.surveymonkey.com/s/borderdatawarehouse.

The primary goal of the questionnaire is to solicit feedback from regional stakeholders to identify applications that a web-based archive could support. Interest in specific applications will help WCOG define the systems requirements for the project.

Each question is listed below along with compiled responses and first observations by WCOG. A final section will summarize observations and identify resulting actions.

2. Agencies who responded to the questionnaire

Niagara International Transportation Technology Coalition (NITTEC), Niagara Falls Bridge Commission (NFBC), New York State Police (NYSP), Buffalo and Fort Erie Public Bridge Authority (BFEPBA), Canada Border Services Agency, New York State Department of Transportation (2), U.S. Customs and Border Protection

3. Questions and responses

Questions are listed below in the same order as the web-based questionnaire. All original responses are given and attributed to the responding agency. Some agencies had two respondents.

Initial observations are listed after each set of responses.

1. What work of your agency/department uses information about cross-border travel demand, changes in cross-border travel time, or distribution/routing of cross-border travel by hour-of-day or day-of-week?

NITTEC	• Disseminate border information to our stakeholders and traveling public • Provide border crossing delay information to the public and stakeholders.

NFBC	We use this data for many different after the fact reporting. We also have a formula that we use currently that predicts wait time that we use to post for travelers approaching the Niagara crossing so they can make an informed decision about which of the four bridges to cross. This information is posted on our telemessage, website and twitter feed.
NYSP	• Traffic control as police officers on I-190 as traffic slows in certain areas based on international bridge crossing delays. • We only deal with Peace Bridge traffic that backs up onto the I-190.
BFEPBA	We utilize a Blue-tooth sensor system to track border wait times. These statistics and wait times are displayed to public on numerous websites and updated every 5 minutes.
CBSA	Responsible for reporting performance and service standards for border wait times
NYSDOT	• Congestion needs, statewide travel demand, and freight movements. • I am involved with the coordination of all border policy for NYSDOT, including working with regional and national border groups on issues that affect NYS borders. Internally we work with our other program areas to insure that the impact of border freight and traffic is properly reflected in investment and operational decisions.
US CBP	CBP uses wait time and processing time data to manage daily port of entry operations (e.g., staffing, lane operations etc.) and for infrastructure planning and improvements.

Initial observations

- The stated interest in reporting performance implies the need for both a time series (an archive of metrics capable of showing changes) and likely a need for other variables such as wait time relative to traffic volume and perhaps the number of open inspection booths.
- Current efforts to provide traveler information, conduct congestion and demand planning, and operations planning based on observed traffic patterns, could all be well served by a more robust and high-resolution archive of system data.

2. What sources and formats of information does your agency/department currently use to inform the types of work you discussed in the previous question?

NITTEC	• Website, email, fax, telephone • Web, DMS, email/text alerts.
NFBC	Telemessage, website, twitter

NYSP	• Generally information is distributed via radio from the state police patrol assigned to and working the post that is affected. • Visual and radio reports of traffic back-ups
BFEPBA	We (our ISP) currently pull the wait time information from an XML web feed/page and parse the data into a web database. The wait time webpages display the latest entries in the database along with a timestamp of when the data was from. We display wait times for autos, trucks, and NEXUS traffic both into and out of Canada at this time.
CBSA	CBSA Border Wait Time Application - manual entry of wait times based on visual indicators and presented in Excel and CSV format
NYSDOT	• Truck classification counts, vehicle miles of travel estimates, and census data. • Internally we rely mostly on our traffic count program that includes continuous coverage stations and multi-day counts performed on a rotational basis. We also have access to data from the Public Border Operators Association and have conducted joint surveys with Ontario for origin-destination and other travel data.
US CBP	CBP uses the wait times it collects and enters on its website for 30 Northern border ports of entry for NEXUS, Ready Lanes, FAST and private vehicle wait times. CBP also uses the Vehicle Primary Client to measure processing times for travelers. The web data and VPC data is electronic.

Initial observations

- Single location wait time data is being stored but not in a way that's widely available (databases, spreadsheets, etc.).
- Informal access to vehicle count data from public border operators could possibly be automated as part of the archive development, providing important variables for system performance measurements.
- Discussions with CBP regarding the potential of exporting selected data elements from the VPC system could also provide corresponding volume data to enable using wait time data as a more meaningful performance metric.

3. The primary measures currently generated by the border wait time systems in the Niagara region are 1) actual wait time (point-to-point measures made at the time of a vehicle's arrival at the primary booth) and 2) current wait time (estimated wait time for the next car that arrives at the end of the queue). It is possible that other regionally-generated traffic data could be included in the border data warehouse. From the list below, please select the types of information that your agency uses or would use if it were available.

Answer Options	**Response Count**	**Agencies***
Actual wait-time (described above)	6	NITTEC, NFBC, NYSP, CBSA, NYSDT
Current wait time (described above)	9	NITTEC, NFBC, NYSP, BFEPBA, CBSA, NYSDT, USCBP
Border traffic volume (in five-minute increments)	9	NITTEC, NFBC, NYSP, BFEPBA, CBSA, NYSDT, USCBP
Vehicle classification	7	NITTEC, NFBC, NYSP, BFEPBA, NYSDT, USCBP
Number of inspection booths open	5	NITTEC, NFBC, BFEPBA, CBSA, USCBP
Vehicle occupancy (number of people in each vehicle)	4	NFBC, NYSDT, USCBP
License plate state or province	3	NFBC, NYSDT, USCBP

*Some agencies had two respondents.

Initial observations

- It is noteworthy that there is equal respondent interest in high-resolution volume data as in wait time data.
- It is interesting that the interest in *current* wait time measures is greater than in *actual* wait times. While both values will be in the archive, this could be interpreted to reflect slightly broader interest in wait times as traveler information than as performance measures.

4. Would newly developed resources like those listed above be a preferred alternative to sources you already use? Please specify.

NITTEC	• Yes, currently do not have some of the information available Web, DMS, email/text alerts.
NFBC	Border Volume - NO we have a reliable system Vehicle Classification - No we

	have a reliable system Number of Inspection Booths Open - No we have a reliable system to determine this Actual Wait & Current Wait-time: We have two new systems being implemented which show some promise. Our current system is reliable. We currently store all our own data on site and have a skilled I.T. Department that can develop reports to pull whatever data we want, whenever we want. So it is likely we would stick to our current sources unless the newly developed data was proven to be more accurate. We have the infrastructure to store mass amounts of data in house.
NYSP	• Yes - currently we react to delays when they begin to slow traffic on the I-190. With advanced warning our post coverage could be adjusted in advance to adjust to the increase in volume.. • No
BFEPBA	Newly developed resources would act as a complement and not an alternative to what we already have.
CBSA	yes as we are currently relying on visual indicators and would prefer accuracy achieved by automation
NYSDOT	• More frequent data could supplement existing data sources. Internally we rely mostly on our traffic count program that includes continuous coverage stations and multi-day counts performed on a rotational basis. We also have access to data from the Public Border Operators Association and have conducted joint surveys with Ontario for origin-destination and other travel data. • The bulk of the data we currently have access is static and reflects a picture at a particular point in time. The new data sources would allow for historical analysis capability and a more nuanced breakdown of actual conditions. For example, the ability to receive border traffic volumes in 5 minute increments exceeds our current capabilities.
US CBP	We would use them both if they had a positive impact on port operations/efficiencies and did not create undo burden on port resources.

Initial observations

- There is stakeholder interest in quality assurance and/or assessments of the wait time system accuracy. This concern has some overlap with including a measure of data quality as an attribute of wait times stored in the archive.
- An interest in "advanced warning" speaks beyond the capabilities of the system and the expectations of this border data warehouse; however, the current warehouse could become a resource for traffic pattern analysis that provides warnings of likely surges in travel demand (at the border or otherwise).

- There is more interest in volume counts that correspond with the frequency of wait time estimates (five-minute measures). This would need data from other sources. Booth clearance volume data (inspection or toll) would work. Queue end arrival data for volume would be best for understanding the traffic demand pressure on the system.

5. Do you foresee opportunities for your department to make first-time use of data and information stored from border wait time systems and other border traffic data collection devices? Please specify.

NITTEC	• Yes for Performance Measures Reporting • Yes, to report border delay times.
NFBC	Yes, if this is where the new systems (MTO & Fed. Highway Project) choose to store the data then we would likely be accessing it to post wait-times for travelers.
NYSP	• Yes - as described above. • Not really
BFEPBA	I think that we would be on the "reporting" side of this information and not necessarily the "user" side of the data. We would want to provide the public with this information, although we would keep track of vehicle counts and their classification for our internal needs as well.
CBSA	yes, since we have a responsibility to resource borders appropriately and to ensure performance meets our service standards.
NYSDOT	• I could see this information being used to manage traffic congestion by informing the traveling public of real-time delay and allowing the traveling public to modify their travel pans to travel during non-peak or non-congested hours. • The new data would be very useful as we move forward with developing a comprehensive freight plan for NYS.
US CBP	Yes, under the binational Beyond the Border initiative CBP intends to deploy new and or leverage existing wait time solutions as long as they are proven accurate, reliable and do not create additional burdens on port operations.

Initial observations

- Performance measures seen as something an archive can greatly improve.
- There is a willingness of other agencies/organizations to report out their data. To the extent possible, the archive should support relatively easy ways for individual agencies to provide

their data (such as crossing-specific volume/arrival rate data) and then support the display of that data alongside the core wait time measures.

- There is still a lot of agency/stakeholder interest in the provision of border wait times rather than use of an *archive* of wait time data. There will likely be more ideas after agencies have a chance to use historic wait time data.

6. If you have specific interests in commercial traffic data that have not been mentioned in answers to previous questions, please expand on commercial traffic data needs that you think could be addressed through better aggregation and archiving or regional cross-border data.

NITTEC	commercial vehicle border delay times.
NFBC	None
NYSP	The only time we would possibly need commercial vehicle information would be during a pro-longed road closure situation.
BFEPBA	I think that we would report border traffic volume data hourly and not by the 5 minute interval mentioned above.
CBSA	same as above
NYSDOT	Truck weight data would be beneficial to collect at the border crossings.
US CBP	

7. It is expected that an online data warehouse of border wait time data (and other corresponding traffic data) would include custom reporting tools -- allowing users to set up reports that are updated per user specifications. Please describe one or more periodic report(s) that you would like readily available.

NITTEC	• Comparison of delay at the 3 mail bridge crossings in Niagara, Total hours of reported delay by month, by day and time of day. Volume of traffic for the 3 main bridges and comparison during major holidays. • Border delays, volumes and booths open.
NFBC	We currently do a report Year over Year (for last 3 years) comparison of # of lanes, volume and delays by hour, by classification, by bridge. We are able to

	generate this currently with our own data that we store.
NYSP	Passenger and Commercial Vehicle traffic counts
BFEPBA	Historical wait times. Traffic volume by day of the week and season. wait times and traffic volumes versus number of booths open.
CBSA	daily or monthly traffic volumes, lane open and the capacity of vehicles per hour through the border
NYSDOT	• Average peak travel delay per month, Average delay per hour • I envision that the reports would be very useful to our regional staff in determining travel patterns during holidays and other heavy travel periods. For example, in western New York there are major impacts at the crossings when the Buffalo hockey team has home games.
US CBP	Ability to run the following historical reports: Daily/weekly/monthly/yearly wait time reports for all ports of entry that collect wait times for all vehicle classification types. - Lane status for NEXUS, FAST, Ready Lanes and pov vehicle lanes. - vehicle arrival rates for all vehicle types

Initial observations

- Again, multiple statements of interest in volume and open-booth counts can be seen.
- Agency feedback on possible database reports seems to underscore that wait-time data alone is less meaningful than a combination of wait times and measures of demand and processing capacity.

8. For inspection agency representatives: What real-time and historical data reporting enhancements would further operational objectives?

CBSA	Daily reports
US CBP	Daily reports

Initial observations

- This should be straight forward and also possible to set up as an e-mail subscription.

4. Conclusions

This section lists consolidated conclusions about how this feedback influences the border data warehouse system development.

Conclusion 1: There is broad interest in wait time measures AND in corresponding measures of traffic volume and numbers of inspection booths open.

> **Response 1a**. Suggest to the Border Wait Time Working Group (BWT) that it identify a preferred traffic volume metric in a similar way to how the BWT has agreed on a common definition of *wait time*. Different locations will have different methods and types of traffic counting but these differences can be explained to data users. A recommended preference is volume data to use alongside wait time data is queue-end arrival volumes captured at a frequency that matches (as closely as possible) the frequency of updates to the wait-time calculation.

> **Response 1b**. A corresponding measure of traffic volume should be considered as a component of the national portal wait time archive as well as the Niagara regional border data warehouse.

> **Response 1c**. WCOG will continue to work with CBP to explore the possibility of exporting selected data (volume, booth status, etc.) from their VPC system.

Conclusion 2. Supporting the ease of adding data feeds to the data warehouse is even more important when the primary sources of volume data will likely not be integrated with the core wait time system.

> **Response 2a**. The potential for individual agencies to deliver volume data to the archive will be added to the system requirements.

Conclusion 3. Tracking data quality (of the wait-time measures) will continue to be of interest to many stakeholders. Along with the wait time values themselves, an indicator of data quality should be explored to accompany values. Note: 'data quality' is not necessarily the same as system accuracy. Optimally, system accuracy should be independently verified on a scheduled basis.

> **Response 3a**. WCOG will follow up with the wait time system vendor to see if there are potential meta-data that can serve this purpose (Blue tooth sample size, number of outliers in the current estimate, standard deviation in the current sample, etc.).

> **Response 3b**. Suggest to the BWT that a wait time system accuracy assurance routine be agreed upon as a shared maintenance objective (ex. 'ground truth' tests every two years or after significant construction or known system alterations).

Conclusion 4. A follow up questionnaire on user needs should be distributed several months after the border data warehouse websites have been set up. It's likely that stakeholders will have many additional ideas for applications after using archived data related to the crossings.

> **Response 4a**. If it fits in the project timeline and budget, a follow-up user needs questionnaire will be sent to original respondents. This will be in addition to feedback gained during beta-testing of the archive website.

Appendix B: Concept of operations

February 26, 2013

1. Introduction

This project will design and implement a binational border data warehouse that will archive delay and other data elements relating to the cross-border movement of vehicles. The purpose of this archive is to provide near real-time data to regional and national stakeholders to help inform policy, investment strategies, and the development of performance measurements.

Background

The U.S. – Canadian Border Wait Time Working Group (BWT) consists of border stakeholder agencies working together to develop national-level standards for reporting cross-border delay. Participating agencies include Transport Canada, U.S. Federal Highway Administration (FHWA), U.S. Customs & Border Protection (CBP), and Canada Border Services Agency (CBSA). In addition to developing a standardized reporting measurement for border delay (from end of queue to arrival at a primary inspection booth), the BWT is also overseeing the deployment of field equipment at the twenty busiest land ports-of-entry between Canada and the United States. To archive data coming off these real-time traveler information systems, Transport Canada and FHWA have funded the Whatcom Council of Governments (WCOG) to develop both a national border data warehouse portal, and a region-specific warehouse at the location of the primary equipment deployment, the Buffalo-Niagara region border crossings.

The Cascade Gateway Border Data Warehouse

WCOG previously developed a regional border data warehouse for the Cascade Gateway system of border crossings between Whatcom County, Washington and the Lower Mainland of British Columbia. This warehouse archives data from B.C. and WA State systems in five minute increments, and makes these data available online in a format that can be easily queried and downloaded. Automated reports are available through the archive for end users or to external websites via an application programming interface (API). And the warehouse has expanded its data output to include data from the U.S. Bureau of Transportation Statistics North American Transborder Freight Data as well as data from a regional weigh-in-motion detector.

WCOG's experience developing and managing this regional border data warehouse has informed the systems engineering work for this project.

A regional and national archive

The project scope described below shows that there will be two products developed: a Niagara Region Border Data Warehouse for their system of four border crossings; and a U.S. – Canada Border Data Warehouse that serves as a portal to both Cascade Gateway and Niagara Regional archives to allow for national-level database queries.

What is a Concept of Operations?

A Concept of Operations is a document that provides high-level identification of user needs and stakeholder agreements on roles and responsibilities for the border data warehouse. It describes:

- Stakeholder roles and responsibilities
- System needs
- The geographic and physical extent of the system
- Sequence of activities performed
- How the system will be developed, operated, and maintained.

Needs identified in this document will be used to identify system requirements that guide design and implementation of the system.

2. Scope of work

The following tasks will be accomplished under the project's scope of work:

1. Establish a project advisory committee
2. Identify owners of the wait time systems and other data sources
3. Document available data and resulting information
4. Identification of users, user needs, and architecture
5. Document system requirements and data transfer schemes
6. Write a scope of work for a third-party developer
7. Manage the development process
8. Develop a scope and strategy for maintenance, backups, and modifications

Details on each of these eight tasks can be found in the U.S. – Canada Border Data Warehouse Expansion Project Proposal document.

3. Stakeholders

Agencies involved in the project include:

- Buffalo & Fort Erie Public Bridge Authority (data provider/end user)
- Canada Border Services Agency (end user)
- Delcan Corporation (data provider)
- Free Ahead Inc. (data provider)
- Ministry of Transportation Ontario (data provider/end user)
- Niagara Falls Bridge Commission (data provider/end user)
- NITTEC (system administrator, end user)
- NY State Department of Transportation, Region 5 (data provider/end user)
- SAIC (data provider)
- Transport Canada (funding agency/end user)
- U.S. Customs & Border Protection (data provider/end user)

- U.S. Federal Highway Administration (funding agency/end user)
- Whatcom Council of Governments (system administrator/end user)
- Other end users (inspection and transportation agencies, tourism organizations, carrier companies, cross-border shippers, customs brokers, transit agencies, researchers, and the traveling public)

4. Referenced documents

Documentation relevant to this Concept of Operations include:

- U.S. – Canada Border Data Warehouse Expansion Project Proposal (June 2012, Whatcom Council of Governments)

5. Current system background

New Bluetooth reader devices have been installed at the bridges connecting Buffalo, NY and Niagara, Ontario as part of the BWT initiative. Data from these readers is processed by Free Ahead Inc., a consulting company that then provides the output in a variety of formats to display actual and current wait times for passenger vehicles crossing northbound and southbound at the Peace Bridge, the Queenston/Lewiston Bridge, and the Rainbow Bridge.

Wait times calculated by the Bluetooth system can be displayed on partner agency websites in real time, including CBP and CBSA's websites, NITTEC's website, and at both the Niagara Falls Bridge Commission and Buffalo & Fort Erie Public Bridge Authority's websites.

Data resulting from the BWT system in this region has been questioned in some cases, leading to efforts to improve the robustness of the data set by installing additional readers, manually updating website information on the part of the Niagara Falls Bridge Commission, and efforts by other stakeholder agencies like the Ministry of Transportation Ontario (MTO) to develop complimentary border wait time measures applying additional technologies such as loop detectors.

Justification for this project

No system is currently in place to archive and make available data coming off the Bluetooth reader system, although the consulting company Free Ahead does have historic data sets from the system. Nor is there any system in place to compare wait time data resulting from the BWT system to wait times in other border regions.

The benefits of providing a web-based, accessible archive of data coming from the wait time system include:

- **Improved cost-benefit ratio**: Historic wait time data may not be the primary purpose traveler information systems are installed, but storing these data for multiple secondary applications increases the value of such a system to multiple parties and for a variety of purposes.

- **Improved performance measurement**: There is no accurate way to determine whether or not a specific roadway or operational improvement has made a positive impact without data. In light of this, such data archives allow for baseline data measurements that can be compared to resulting data after a change in operations, policy, or infrastructure is made to measure change.
- **Increased range of end users**: Data pertaining to which border crossing is faster at a given time is useful for the traveling public crossing the border in the Buffalo-Niagara region but has little importance to national-level decisions regarding border management. However if data from that system can be analyzed in conjunction with wait time reports from other regions, comparisons can be made that will assist decision-making on a larger national level.
- **Improved information access to stakeholders**: border data warehouse functions will include subscriptions that allow individuals or agencies to get notification of particular delays as they happen, which may help inform operations.
- **Improved situational awareness**: With more data available to facility managers and system operators they are able to provide new tools for improving safety, efficiency, and resource allocation.
- **Supports tourism and trade along transportation corridors**: The wait time systems themselves support tourism, trade, and cross-border traffic flows in general by removing a significant amount of uncertainty for drivers and, in some cases, providing the needed information for rerouting. This project builds on the real-time information to ensure that traffic information can be used to further optimize cross-border transportation efficacy to benefit all affected economic sectors.

Available data

The BWT Bluetooth system provides real-time border wait times for passenger vehicles and for NEXUS cars as well as for commercial vehicles. These data may be made available at a centralized FTP location for pick up by the border data warehouse.

Other possible data

In addition to the Bluetooth data sets, NY State Department of Transportation (NYSDOT) collects Transcom system toll tag data to develop corridor segment travel times, of which border-specific routes could be archived along with border wait times within the archive.

The Buffalo and Fort Erie Bridge Commission collects vehicle counts at Peace Bridge that may be archived alongside the Bluetooth data for that crossing.

CBP may be able to provide real-time booth status data which would allow datasets to dynamically update what type of vehicle (e.g.. standard user, NEXUS, Ready Lane, etc.) is using a specific booth. Solutions to provide this information dynamically are being pursued for the Cascade Gateway traveler information system in order to improve system accuracy and to avail program-specific data results for analysis. If such a tie-in between transportation and inspection agency information systems is made available at one location, it may be also available along the whole border.

6. Concept for the proposed system

There are two components for the proposed system, described below:

Niagara Region Border Data Warehouse

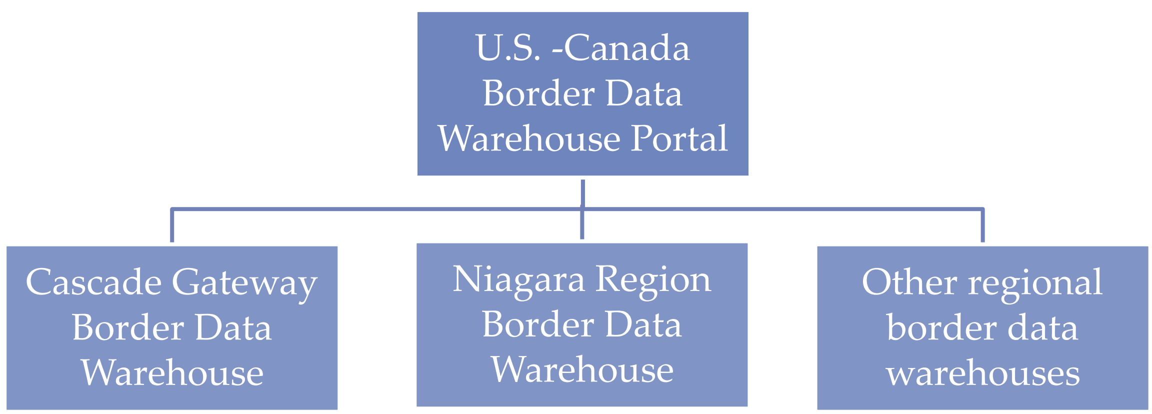
This system will collect data from the Free Ahead Bluetooth system at the Peace, Queenston-Lewiston, and Rainbow bridges via FTP or other web connection, classify and perform quality checks on incoming data, and then display the data online for end users rolled into five-minute increments.

The system will also potentially collect related data in a similar manner including traffic volumes, booth status data, corridor segment travel times, etc.

All data will be stored in a database that can be accessed and queried like the existing Cascade Gateway Border Data Warehouse available at www.cascadegatewaydata.com.

U.S. – Canada Border Data Warehouse

This system will serve as a portal to the Niagara and Cascade Gateway regional data warehouses, and other regional border data warehouses that come online in the future. It will pull common factor data sets (i.e. wait times) from each archive and display comparable results online.



7. User-oriented operational description

The U.S. – Canada Border Data Warehouse is envisioned to be a fully functional data archive designed to serve the needs of multiple types of end users. This chapter describes how the system will operate from perspectives of different user classes.

Traveler's perspective

The cross-border traveler will mostly interact with the advanced traveler information systems provided on other regional websites. However, if they are interested in looking at *historic* wait time data to better estimate potential border delays, they may use the archive.

For these end users, they will need an interface that is easy to understand and which responds to a geographic map-based landscape they are familiar with. They should be able to find the port-of-entry, direction, month, day of week, and time of day they are looking for expeditiously and easily call up comparable information.

Inspection agency perspective

Inspection agencies will find different value from the border data warehouse than the traveling public. The system must be designed in a way that makes it quick and easy for agencies to run complex time, date, direction, and location queries and to have data output in a variety of measures including average, minimum, maximum, etc. This can help with resource allocation, forecasts of travel patterns based on past conditions, and analyses of the functionality of specific lane types.

To maximize the benefit of the data, customizable subscriptions should be designed to allow agencies to be alerted as certain thresholds of delay are reached so they may respond.

Unlike the traveling public, inspection agencies may also benefit from being able to query the data by individual device when applicable; therefore they can better determine where delays occur within a closed system.

Data and reports from the warehouse should be available via an API so that inspection agency websites can link directly to current outputs from the archive and display historic data without needing to reproduce information.

Transportation and regional planning agency's perspective

Similar to inspection agencies, transportation and regional planning agencies may use the website archive as a tool for analyzing current operations in light of upcoming changes, or to determine resource allocation based on traffic patterns established by analyzing historic data.

They should also be able to query the data at a much higher resolution than is currently available such as by hour, by individual detector or by segment, allowing for a clearer picture of how the system as a whole functions.

Transportation agencies and regional planning organizations may also want to use the system API to display report results on their own websites.

Private party developer's perspective

Private developers of website and smart phone applications should be able to access the root database through a secure API which would allow them to use public data in whatever program they design. An example might be the development of an historic waits app which would allow end users to put in a date, time of day, and crossing and pull up historic records of wait times to develop an average of what they can expect to experience at the border.

8. Operational needs

Project goals identified in the original proposal are to:

1. Build on the model of the Cascade Gateway Border Data Warehouse by designing and deploying a similar system for the Niagara region border crossings.
2. Develop a U.S. – Canada border-wide web portal for these and future regional wait time archives.
3. Complete this work in a way that advances a standard approach for continued deployment as other border wait time systems are implemented.

Based on data collected from a regional user needs survey, the following needs were identified by those who plan on sharing data with the system and/or using the data warehouse.

Build a Niagara region border data warehouse and an accompanying U.S. – Canada web portal

Interoperability needs

1. The warehouse needs to be developed in compliance with Section 508 of the Rehabilitation Act of 1973 as amended (29 U.S.C. 794d) and in compliance with the international Web Content Accessibility Guidelines (WCAG) for accessibility for all users.
2. The warehouse needs to be developed with templates that make it clearly viewable on a variety of devices including but not limited to computers, smart phones, and tablets.
3. The warehouse needs to provide data in a downloadable and exchangeable format usable on multiple platforms.
4. The warehouse needs an API interface to allow the data to be used by other websites, agencies, or applications for greater dissemination of data.
5. The warehouse needs to be designed in a way to provide data not only to the Buffalo-Niagara Region Border Data Warehouse website, but to the U.S. – Canada Border Data Warehouse website.

User functionality needs

6. The warehouse needs a map view showing crossing locations for users to access port-level data.
7. The warehouse needs a map view showing detector locations.
8. The warehouse needs to display data in a clean, easy to understand calendar format.
9. The warehouse needs to display a variety of data sets.
10. The warehouse needs to provide all data components in a downloadable format.
11. The warehouse needs to display reports that can be defined from custom queries by the administrator.
12. The warehouse needs a custom query tool that allows for multiple aggregations as defined by the end user.
13. The warehouse needs a help system that provides information on how to use each page.
14. The warehouse needs a color-coded flagging system (i.e. green for good, yellow for caution, red for danger) for each day or month of the day/month view that has a data feed that may be erroneous or incomplete.

15. The warehouse needs an automated email subscription service for reporting delay that users may subscribe/unsubscribe to and define the threshold of delay and crossings they are interested in.
16. The warehouse needs an automated email subscription service for delivering static reports to users that subscribe/unsubscribe to the service.

Administrative functionality needs

17. The warehouse should be updated at least every hour and as close to the source system frequency as is practical.
18. The warehouse needs to allow administrators to save a custom query as a static report that can be dated for an end date in the future.
19. The warehouse help sections need to be designed for administrators to edit.
20. The warehouse needs an automated delay subscription service that allows administrators to manage subscriptions for individuals.
21. The warehouse needs an automated email subscription service for delivering static reports to users that subscribe/unsubscribe to the service.
22. The warehouse needs to alert administrators when new hardware is detected by the system.
23. The warehouse needs to allow administrators to enter or alter geo-coded mapped information for crossings and devices.
24. The warehouse needs to be designed in a way that alerts administrators of the health of the warehouse.

Growth and maintenance management needs

25. The warehouse needs to be designed in a way that makes it simple to modify and maintain.
26. The warehouse needs to be built for future expansion and increased archiving requirements.
27. The warehouse needs to be accessible and queriable quickly and efficiently.
28. The warehouse needs to be designed to automatically detect new data sources in the system and store that new data appropriately.
29. Documentation needs to be developed in such a way that the functionality and maintenance of the warehouse is clear for future developers.
30. Database and website formats need to be in an industry-standard programming language that allows for multiple developers to easily understand and address future issues.
31. A security audit of the warehouse needs to be completed and the conclusion of the project to alert administrators of any possible risks to the database.

Advance a standardized schema

1. The system needs to develop a standardized data transfer schema that allows participating data providers to format their data in a single format that allows for transfer and usage amongst a variety of data warehouses.

9. System environment

Geographic environment

The Niagara Region Border Data Warehouse includes three border crossings between Buffalo, New York and Municipalities around Niagara, Ontario. The U.S. – Canada Border Data Warehouse will connect to data from the Niagara region as well as data from the Cascade Gateway Border Data Warehouse, which stores data from the Cascade Gateway ports-of-entry between Whatcom County, Washington and the Lower Mainland of British Columba.

Operational environment

Given the growth potential of the U.S. – Canada Border Data Warehouse, both archives, along with the Cascade Gateway Border Data Warehouse, will be moved to servers on a cloud interface. This will accommodate future growth. Initial maintenance of these servers will be overseen by WCOG in partnership with the system development firm.

Hardware used to collect the data is maintained by participating agencies. The final ownership of equipment installed as part of the BWT initiative has yet to be determined.

10. Operational scenarios

Operational scenarios help convey what is expected to be achieved with the implementation of the border data warehouse project. The following scenario has been developed with members of the project advisory team to illustrate how the warehouses of the project will function. "System Manager" refers to the agency responsible for the maintenance of the warehouse. At development this will be WCOG, however it may be a different organization after completion of this project.

The operational scenarios are grouped into the following types:

- Routine Operation
- Failures and Other Unusual Events
- Design, Implementation, and Upgrades

Routine operational scenarios

The following examples illustrate typical usage of the border data warehouse.

Researcher compiling statistics

A researcher at a college in the Buffalo/Niagara region is interested in seeing if there is a correlation between border traffic and the weather.

After gathering daily temperatures for the entire year of 2013, the researcher visits the Niagara Region Border Data Warehouse and goes to the custom query section of the website. There the researcher specifies that he wants daily averages of wait time for passenger vehicles crossing the three regional ports-of-entry, between the hours of 8am and 8pm. The query results are downloadable, so he downloads the .csv file to be opened in Excel.

Realizing that wait time alone isn't a full picture of cross-border traffic, the researcher also runs a custom query to pull up daily traffic volumes collected from bridge authority field equipment.

To determine if any impact perceived is regional in nature or a national trend, the researcher then visits the U.S. – Canada Border Data Warehouse through a link on the website and runs a national level custom query, seeing how Niagara wait times compare to those in the Cascade Gateway region.

Because the data is downloadable by a variety of measurements, for a specific date range and/or time range, the researcher is able to get the data directly in a format he needs to run an analysis.

Transportation agency staff

A staff member at the state or provincial transportation agency is interested in seeing how a recently added traffic signal is impacting delay at a specific border crossing. She visits the Niagara region border data warehouse and pulls up the general crossing tab and picks the specific crossing she's interested in. Then she views the delay data in a monthly calendar view, looking to see if wait time averages have altered since the installation of the signal.

Seeing that there may be an impact, she then goes to the report section and views a more detailed report that shows average wait times for that crossing and direction broken into weekday and weekend peak hours. Comparing the weekend averages before and after the installation, she is able to determine that the installation has had no negative effect on border queue.

Inspection agency staff

An inspection officer in charge of resource allocation signs up for a subscription service that alerts her any time wait times exceed 50 minutes at a particular crossing. Her phone rings when she gets an incoming email, and the subscription alerts her that a 50 minute delay has been posted within that five minute increment. Now she is alerted prior to delays reaching a 60 minute reporting mark that additional booths need to be opened.

Failures and other unusual scenarios

System managers

A system manager checks his email in the morning and sees a daily notification from the border data warehouse that reports what percentage of data packets have been received for every single crossing in the system.

Usually this email lists every crossing at 100 percent. Occasionally some data packets may be missing or one entire crossing or sector does not have data, suggesting an equipment failure of the field equipment.

If the list reports none of the data feed has been collected the day before, then the system manager knows the problem is more likely to be due to a break in the communication between the warehouse and the data provider. The system manager calls the website developer to inform them of the situation and ask them to check the logs of the feed. If everything is working properly from the warehouse end, the next set of calls is to the data provider to find out what may have altered the feed connection from their end.

Once the connection is re-established, the data warehouse is designed to go back and collect any old data it does not already have stored in its database. The missing data sets are populated into the system.

Design, implementation and upgrade scenarios

System managers

After the border data warehouse is up and running and populated with data, users may contact the system manager with proposed changes or additional data sets.

The system manager will document each request as either a critical repair – if something is not functioning as intended; as an enhancement – if the suggestion improves and existing function; or as an additional service – adding functionality not originally specified in the system requirements document.

The enhancements will be seen to in that order based on available funding, timelines, and the priorities of the project advisory team. Upgrades to the system will be catalogued in the same manner as suggested by the software developers and system managers.

11. Summary of impacts

The following lists potential responsibilities to participating agencies as the border data warehouse system is deployed:

WCOG: WCOG will work with the advisory team, system managers, end users, and the system developers as the administrator of the system over the next year. WCOG will also work with the developers to move the Cascade Gateway Border Data Warehouse to the same secure server location for easier management. There may be additional work required with any additional data-sharing partners.

FREE AHEAD: The consulting firm responsible for the Bluetooth devices and data feeds will need to work with WCOG and WCOG's system developers to identify the means to transfer the data via FTP or similar secure protocol. Free Ahead will also be responsible for sharing the GPS points of all equipment currently installed and reporting as part of the delay system.

Bridge Authorities: The Buffalo & Fort Erie Public Bridge Authority and the Niagara Falls Bridge Commission may be asked to share traffic volume detector data they collect via FTP or similar secure protocol to the archive.

Ministry of Transportation Ontario: If they proceed with installation of border traffic loop detectors, they will be asked to share data from their wait time system to the archive via FTP or similar secure protocol.

U.S. Customs & Border Protection: WCOG will continue to work with CBP to explore opportunities to transfer real-time booth status data to the warehouse to help improve data accuracy regarding alternating booth types as well as to provide other data including volume and state/province of vehicle registration.

NY State Department of Transportation: NYSDOT will potentially be asked by WCOG to share regionally-relevant volume data collected real-time with the archive and transfer that data dynamically via FTP or other secure protocol.

Evaluation metrics

The following are potential measures of the border data warehouse system's performance:

- Availability and access to data
- Presentation of the data in a clear and concise format
- Number of individuals signed up for automated e-mail alerts
- Functionality of administrative back-end
- Ease of updating and maintaining warehouse
- Data upload consistency and accurate logging
- Overall speed of the database

Appendix C: System validation plan

April 30, 2014

1. Introduction

This project will design and implement a binational border data warehouse that will archive delay and other data elements relating to the cross-border movement of vehicles. The purpose of this archive is to provide near real-time data to regional and national stakeholders to help inform policy, investment strategies, and the development of performance measurements.

Background

The U.S. – Canadian Border Wait Time Working Group (BWT) consists of border stakeholder agencies working together to develop national-level standards for reporting cross-border delay. Participating agencies include Transport Canada, U.S. Federal Highway Administration (FHWA), U.S. Customs & Border Protection (CBP), and Canada Border Services Agency (CBSA). In addition to developing a standardized reporting measurement for border delay (from end of queue to arrival at a primary inspection booth), the BWT is also overseeing the deployment of field equipment at the twenty busiest land ports-of-entry between Canada and the United States. To archive data coming off these real-time systems, Transport Canada and FHWA have funded the Whatcom Council of Governments (WCOG) to develop both a national border data warehouse portal, and a region-specific warehouse at the location of the primary equipment deployment, the Buffalo-Niagara region system of border crossings.

Purpose of this validation

The purpose of this plan is to validate the development and deployment of the Niagara Region Border Data Warehouse and the U.S.-Canada Border Data Warehouse.

2. Scope of work

The following tasks will be accomplished under the project's scope of work:

9. Establish a project advisory committee
10. Identify owners of the wait time systems and other data sources
11. Document available data and resulting information
12. Identification of users, user needs, and architecture
13. Document system requirements and data transfer schemes
14. Write a scope of work for a third-party developer
15. Manage the development process

16. Develop a scope and strategy for maintenance, backups, and modifications

Details on each of these eight tasks can be found in the U.S. – Canada Border Data Warehouse Expansion Project Proposal document.

3. Stakeholders

Agencies involved in the project include:

- Buffalo & Fort Erie Public Bridge Authority (data provider/end user)
- Canada Border Services Agency (end user)
- Delcan Corporation (data provider)
- Free Ahead Inc. (data provider)
- Ministry of Transportation Ontario (data provider/end user)
- Niagara Falls Bridge Commission (data provider/end user)
- NITTEC (system administrator, end user)
- NY State Department of Transportation, Region 5 (data provider/end user)
- SAIC (data provider)
- Transport Canada (funding agency/end user)
- U.S. Customs & Border Protection (data provider/end user)
- U.S. Federal Highway Administration (funding agency/end user)
- Whatcom Council of Governments (system administrator/end user)
- Other end users (inspection and transportation agencies, tourism organizations, carrier companies, cross-border shippers, customs brokers, transit agencies, researchers, and the traveling public)

4. Referenced documents

Documentation relevant to this Validation Plan include:

- U.S. – Canada Border Data Warehouse Expansion Project Proposal (June 2012, Whatcom Council of Governments)
- Concept of Operations for the U.S. – Canada Border Data Warehouse (February 2013, Whatcom Council of Governments)
- System Requirements for the U.S. – Canada Border Data Warehouse (February 2013, Whatcom Council of Governments)

5. Validation conduct

Participants

The project is managed by the **Whatcom Council of Governments**. WCOG is responsible for all project management documentation and systems engineering. WCOG is responsible for managing the finances of the project and distributing deliverables from the project. WCOG is also responsible for maintaining the final warehouse for one year after the completion of the project.

The **Project Advisory Team** is advising work on the project and meets at intervals through the project to discuss work to date, decisions regarding system implementation, and to work on follow-on tasks including the addition of new data sets to the archive. The advisory team is responsible for reviewing the work and assuring it fits the needs of partner agencies.

The **chosen consultant** will be selected through a request for proposals process and will be responsible for completing the warehouse programming and development of the two websites. They will work directly for WCOG and will meet the terms established in the established contracts once chosen.

Location

The Niagara Region Border Data Warehouse will be a virtual warehouse on a cloud-based server. The data it stores will be for the broader Niagara Region including three specific land ports-of-entry: The Peace Bridge, the Queenston-Lewiston Bridge, and the Rainbow Bridge. All bridges serve the Buffalo, New York/Niagara, Ontario region.

The U.S. – Canada Border Data Warehouse will be a portal to both the Niagara and Cascade Gateway regional data warehouses, and any future border data warehouses that come online in the future. As such its geographic coverage is the entire U.S. – Canada border.

Schedule

Validation will occur throughout management of the project, and terminate with a validation report at the end of the project in March, 2014.

System hardware/software specifications

System hardware and software specifications will be determined as part of the development process and based on information from the chosen developers. It will most likely be built using SQL Server technology on a Microsoft platform server, with programming completed in .NET code so that any certified .NET developer will be able to make modifications.

Strategy for anomalies

Should system anomalies occur during the project, an advisory team meeting will be called to discuss problems and options for resolving the issue. The Concept of Operations and subsequent documentation will be updated to represent any changes made based on anomalies.

If anomalies occur after completion of the archive and websites, and they can be repaired within the maintenance plan and budget of the project, repairs or corrections will be authorized by WCOG. Anything beyond this in terms of error, cost or scope will be brought forward to the advisory team for discussion.

6. Validation event identification

Based on the Systems Requirements, the following traceability matrix was developed and used at the end of the project to determine which basic operational needs developed during the system requirements phase have been met, and if not, why not.

REQUIREMENT	STATUS	B= Buffalo Niagara only	NOTES
1. The warehouse needs to be developed in compliance with Section 508 of the Rehabilitation Act of 1973 as amended (29 U.S.C. 794d) and in compliance with the international Web Content Accessibility Guidelines (WCAG) for accessibility for all users.		✓	Designed to compliance - full test run using 3rd party software not complete.
1.1. Warehouse developers shall design the website to be U.S.C. Section 508 compliant and run compliancy checks prior to project finalization.		✓	
1.2. Warehouse developers shall design the website to be compliant with World Wide Web Consortium's (W3C) WCAG 2.0 except for the content listed in the Treasury Board of Canada exclusion list (http://www.tbs-sct.gc.ca/pol/doceng.aspx?id=23601&section=text#appB).		✓	
1.3. Warehouse developers shall show administrators how to maintain the website in such a way as to continue to keep all aspects of the site accessible to all users.		✓	
2. The warehouse needs to be developed with templates that make it clearly viewable on a variety of devices including but not limited to computers, smart phones, and tablets.		✓	
3. The warehouse needs to provide data in a downloadable and exchangeable format usable on multiple platforms.		✓	
4. **The warehouse needs an API interface to allow the data to be used by other websites, agencies, or applications for greater dissemination of data**. 4.1. The warehouse shall have an application programming interface (API) component to allow data to be shared with other websites. 4.2. The API shall be designed in such a way as to maintain the security and integrity of the original database.		✓ ✓ ✓	
5. The warehouse needs to be designed in a way to provide data not only to the Buffalo-Niagara Region Border Data Warehouse website, but to the U.S. – Canada Border Data Warehouse website.			Data stored in central database for both sites
User functionality needs			
6. The warehouse needs a map view showing crossing locations for users to access port-level data. 6.1. The warehouse shall use an online mapping system to display crossings. 6.2. Crossings shall be available for each direction. 6.3. Clicking on a crossing icon shall direct a person to a calendar view of that crossing's data.		✓ ✓ ✓ ✓	
7. The warehouse needs a map view showing detector locations.		B	Valid for Buffalo site only

7.1. The warehouse shall use an online mapping system to display devices.		B
7.2. The map shall be zoomable to allow end users to select specific devices from the map itself if applicable data is available.		B
7.3. The warehouse shall allow users to select multiple devices on the map that will then populate a custom query field if applicable data is available.		B
8. The warehouse needs to display data in a clean, easy to understand calendar format.		✓
8.1. The warehouse shall separate out data sets using tabs at the top of the page for each data type.		✓
8.2. The warehouse shall display each data type in a similar manner.		✓
8.3. The data shall be presented in calendar format.		✓
8.4. The data shall also be presented in data tables and charts.		✓
8.5. The data shall be viewable by port-of-entry.		✓
8.6. The data shall be viewable by direction.		✓
8.7. If detector-level data are available, they shall be viewable by detector.		B
8.8. The warehouse shall be designed in such a way that different border traffic types can be reported separately or in aggregate, by port location, and by direction. These include regular passenger vehicles, NEXUS passenger vehicles, Ready Lane passenger vehicles, regular commercial trucks, FAST program trucks. Flexibility should be maintained to add future traffic types if needed.		✓
8.9. Data charts shall be printable and downloadable.		✓
8.10. Data charts shall be dynamic and allow for end user customization of scales, timelines, and comparisons.		✓
9. The warehouse needs to display a variety of data sets.		✓
9.1. The data shall be stored in current, actual, and predictive formats where available.		B
10. The warehouse needs to provide all data components in a downloadable format.		✓
10.1. Warehouse data shall be downloadable in a .CSV format.		✓
11. The warehouse needs to display reports that can be defined from custom queries by the administrator.		✓
11.1. Reports shall be viewable on screen or downloadable as .CSV files.		✓
11.2. The Reports section of the website shall provide a list of compiled reports for viewing.		✓
11.3. The reports shall be designed in such a way that they are kept current (i.e. new data is included in the report query).		✓
12. The warehouse needs a custom query tool that allows for multiple aggregations as defined by the end user.		✓
12.1. The query tool shall result in multiple output types including data table, chart, and downloadable .CSV file.		✓
12.2. The query tool shall allow users to select date ranges, days of the week, and hour ranges.		✓
12.3. The query tool shall allow users to group, summarize, and generate descriptive statistics for data by month, day of week, day, am/pm, hourly, by five minute increment.		✓

12.4. The query tool shall allow users to group by regular passenger vehicles, NEXUS passenger vehicles, ReadyLane passenger vehicles (if data is available), regular commercial trucks, FAST program trucks.		✓
12.5. The query tool shall allow users to query multiple devices (if applicable) or crossings at a time.		✓
12.6. The query tool shall allow users to query multiple crossing locations at a time.		✓
12.7. The query tool shall report times on a 24-hour clock (00:00 – 23:59) in the local time zone of the crossing location.		✓
12.8. The query tool shall allow users to aggregate data by various measures including average, max, min, and sum values.		✓
12.9. The query tool shall allow users to view multiple measures of data (if applicable) in one query (i.e. volume, wait times, etc.).		B
12.10. Query tool results shall be available as a unique URL so the custom query may be emailed or shared with other partners.		✓
13. The warehouse needs a help system that provides information on how to use each page.		✓
13.1. Both websites shall have help links on each page that links to a pop-up/section of the page with useful instructions.		✓
13.2. Help resources shall include short explanations of how each set of archived data is generated and what it represents.		✓
14. The warehouse needs a color-coded flagging system (i.e. green for good, yellow for caution, red for danger) for each day or month of the day/month view that has a data feed that may be erroneous or incomplete.		✓
14.1. The warehouse shall display color coded symbols on each calendar or day view relating to the percentage of data packets received.		✓
14.2. The website shall display warnings to users who run queries using data flagged as red.		✓
15. The warehouse needs an automated email subscription service for reporting delay that users may subscribe/unsubscribe to and define the threshold of delay and crossings they are interested in.		✓
15.1. The warehouse shall allow users to sign up for automated email reports of delay.		✓
15.2. Users shall be able to define the ports, directions, and traffic types they are interested in.		✓
15.3. Users shall be able to define the threshold of delay they are interested in.		✓
15.4. Users shall be able to unsubscribe from these reports at any time.		✓
15.5. Users should be able to define how often they want e-mail alerts (ex. daily, hourly, when defined threshold is met, etc.)		✓
16. The warehouse needs an automated email subscription service for delivering static reports to users that subscribe/unsubscribe to the service.		✓
Administrative functionality needs		
17. The warehouse should be updated at least every hour and as close to the source system frequency as is practical.		✓
18. The warehouse needs to allow administrators to save a custom query as a static report that can be dated for an end date in the future.		✓
18.1. Administrators shall be able to design and save any custom query as a report.		✓

18.2. Administrators shall be able to delete or rename any report.		✓
18.3. Administrators shall be able to organize the list of reports.		✓
19. The warehouse help sections need to be designed for administrators to edit.		✓
19.1. Administrators shall be able to add, edit, and delete content for each help section.		✓
19.2. Administrators shall be able to use HTML code within the help section to format text.		✓
20. The warehouse needs an automated delay subscription service that allows administrators to manage subscriptions for individuals.		✓
20.1. The warehouse delay subscription service shall allow administrators to see the email addresses and subscription details of all those subscribed to the email alert system.		✓
20.2. The warehouse delay subscription service shall allow administrators to sign individuals up by entering an email address, port(s) and direction(s) of interest, and threshold of delay.		✓
20.3. The warehouse delay subscription service shall allow administrators to delete subscriptions.		✓
21. The warehouse needs an automated email subscription service for delivering static reports to users that subscribe/unsubscribe to the service.		✓
21.1. The warehouse report subscription service shall allow administrators to see the email addresses and subscription reports of all those subscribed.		✓
21.2. The warehouse report subscription service shall allow administrators to sign individuals up by entering an email address, frequency of reporting updates, and the name of the static report(s).		✓
21.3. The warehouse report subscription service shall allow administrators to delete subscriptions.		✓
21.4. E-mail subscription services shall generate an alert to subscribers when subscription-based alerts or reports are removed.		✓
22. The warehouse needs to alert administrators when new hardware is detected by the system.		B
22.1. The warehouse shall send an email to administrators when new hardware is detected.		B
22.2. The warehouse shall alert administrators when devices have been detected that are not mapped.		B
23. The warehouse needs to allow administrators to enter or alter geo-coded mapped information for crossings and devices.		B
23.1. The warehouse shall allow administrators to edit the geo-location of each device and automatically display this detector on the map.		B
23.2. The warehouse shall allow administrators to edit crossing locators on the map.		✓
24. The warehouse needs to be designed in a way that alerts administrators of the health of the warehouse.		✓
24.1. The warehouse shall send daily reports to registered administrators showing a health snapshot of the data.		✓
24.2. The warehouse shall send reports to administrators when data connections are broken.		B
24.3. The warehouse shall alert administrators when devices are not mapped to the system.		B

24.4. When applicable, a border crossing that does not have one or more volume detectors selected shall alert the administrator.		B
24.5. The warehouse shall alert administrators if the storage of the server reaches critical capacity.		✓
Growth and maintenance management needs		
25. The warehouse needs to be designed in a way that makes it simple to modify and maintain.		✓
25.1. The warehouse shall allow administrators to add or edit data feeds into the system.		✓
26. The warehouse needs to be built for future expansion and increased archiving requirements.		✓
26.1. The warehouse shall be designed in such a way that additional storage capacity can be added without redesigning the warehouse structure.		✓
26.2. The warehouse shall be designed to store differing types of data and different file types.		✓
26.3. The warehouse shall be designed in such a way that allows for expanding data types across the tabbed menu bar.		✓
26.4. The custom query shall allow users to query all the different data types available.		✓
27. The warehouse needs to be accessible and queriable quickly and efficiently.		✓
27.1. There shall be no more than a five second delay for each page load on the website.		✓
27.2. There shall be no longer than a 10 second delay for downloading large custom queries.		✓
27.3. Queries that are too large to display will result in instructions to the user to download the file.		✓
27.4. The warehouse shall be stored on a server with enough capacity to house rapidly increasing volumes of data.		✓
27.5. The warehouse shall be stored on a server designed in such a way that website functionality is separated from data storage to facilitate faster response times.		✓
27.6. Warehouse data backups shall be stored in a location that will not impact the speed or functionality of the website.		✓
28. The warehouse needs to be designed to automatically detect new data sources in the system and store that new data appropriately.		B
28.1. The warehouse shall use the XML schema to automatically store new hardware and data feeds.		✓
28.2. The warehouse shall send the administrator an alert when new data feeds are detected.		B
28.3. The warehouse shall provide steps for administrators to customize information for each new port-of-entry or detector.		B
29. Documentation needs to be developed in such a way that the functionality and maintenance of the warehouse is clear for future developers.		✓
29.1. Warehouse developers shall develop documentation on how the warehouse has been built; hardware specifications; programming knowledge needed; and how and where data are stored.		✓
29.2. Warehouse developers shall prepare documentation on how the warehouse should be maintained.		✓
29.3. Warehouse developers shall prepare documentation on how administrators can make changes to the warehouse.		✓

Need to discuss how sites would be added.

30. Database and website formats need to be in an industry standard programming language that allows for multiple developers to easily understand and address future issues.		✓	
30.1. The warehouse shall be designed using a common programming language and on a common server operating system.		✓	
30.2. Any customized components of the warehouse shall be described in detail in documentation with instructions on how that component ties into the full warehouse.		✓	
31. A security audit of the warehouse needs to be completed and the conclusion of the project to alert administrators of any possible risks to the database.		✓	Security audit to be completed by third party software solution, not included here.
31.1. No personal identifiable information (PII), including MAC addresses, shall be stored in the database.		✓	

Appendix D: Project architecture

March 31, 2014

1. Introduction

This project implemented a binational border data warehouse to archive cross-border wait time estimates at border crossings along the U.S. – Canada border. The archive now provides near real-time data to regional and national stakeholders to help inform policy, investment strategies, and the development of performance measurements.

Background

As border wait time systems are developed across the U.S. – Canada border, public and private stakeholders have a shared interest in storing this valuable time series traffic data for multiple uses and applications. In consultation with the Border Wait Time Working Group, the Whatcom Council of Governments (WCOG) developed a binational portal of archived wait time data online to serve the multiple needs of stakeholder agencies and the serve as a clearinghouse for comparable border data.

The new binational Border Data Warehouse (BDW) is based on previous work WCOG accomplished on a regional border data archive called the Cascade Gateway Border Data Warehouse, located at: www.CascadeGatewayData.com.

Using a similar XML schema and development platform, WCOG created two new online warehouses –the BDW for archiving wait time delay only from all accessible border crossing wait time systems; and a regional data warehouse for the Buffalo/Niagara region that specifically stores datasets unique to the area's crossing delay system.

This architecture is for the national instance only.

2. Scope of the architecture

2.1 Geographic scope

The BDW is for border crossings along the entire U.S. – Canada border. For this version of the architecture, two regional crossing systems are included in the BDW: the Cascade Gateway region's four land ports-of-entry (Peace Arch/Douglas, Pacific Highway, Lynden/Aldergrove, and Sumas/Abbotsford-Huntingdon) and Niagara region's ports-of-entry that have Bluetooth wait time detection systems (Peace Bridge and Lewiston-Queenston Bridge).

2.2 Timeframe

This project started in 2013 and the archive will operate until March 31, 2015 until additional funding is available.

3. Stakeholders

Agencies involved in the project include:

- Buffalo & Fort Erie Public Bridge Authority
- Canada Border Services Agency
- Free Ahead Inc.
- Niagara Falls Bridge Commission
- Transport Canada
- U.S. Customs & Border Protection
- U.S. Federal Highway Administration
- Whatcom Council of Governments
- Other end users (inspection and transportation agencies, tourism organizations, carrier companies, cross-border shippers, customs brokers, transit agencies, researchers, and the traveling public)
- Other databases and applications

4. Operational Concept

This section defines each stakeholder's current and future roles and responsibilities in the operation of the BDW.

All roles and responsibilities are under the BDW Archived Data Systems project area.

Buffalo & Fort Erie Public Bridge Authority (BFEPBA)

- Collect and disseminate Bluetooth system data

The Buffalo & Fort Erie Public Bridge Authority took over ownership and maintenance of the Bluetooth wait time detector system installed by the BWT Working Group in 2013. They maintain the equipment with a private consulting firm.

Niagara Falls Bridge Commission (NFBC)

- Collect and disseminate Bluetooth system data

The Niagara Falls Bridge Commission took over ownership and maintenance of the Bluetooth wait time detector system installed by the BWT Working Group in 2013. They maintain the equipment with a private consulting firm.

Whatcom Council of Governments (WCOG)

- Maintain BDW archive and website
- Maintain the Cascade Gateway Border Data Warehouse

The Whatcom Council of Governments developed the BDW and will maintain the BDW through March 31, 2015.

The Whatcom Council of Governments also developed the regional Cascade Gateway Border Data Warehouse and will maintain this system until 2018.

5. Inventory

The data collection systems in operation as listed above are defined below by stakeholder. Note that the stakeholders may have other ITS systems in the region, or that other stakeholders may have systems, but they are not included in the table since they do not relate specifically to the automated sharing of data in this specific project.

Stakeholder	Element	Description	Subsystems & Terminators	Status
BFEPBA	Bluetooth Field Equipment	Field equipment initially installed and operated by Free Ahead Inc. to measure wait times.	Roadway Subsystem	Existing
NFBC	Bluetooth Field Equipment	Field equipment initially installed and operated by Free Ahead Inc. to measure wait times.	Roadway Subsystem	Existing
Other databases and applications	Systems using warehouse API	Agency systems that use data put into the warehouse or archives	Archived Data User Systems (Terminator)	Planned
Private Travelers	User Information Device	Personal computers, PDAs, web-enables cell phones, etc. used by individuals to access information concerning traffic conditions, trip planning, and border crossing information	Personal Information Access	Existing

Stakeholder	Element	Description	Subsystems & Terminators	Status
WCOG	Border Data Warehouse	Data collection and warehousing system to collect transportation-related information from the region. Archived data used to support planning activities.	Archived Data Management Subsystem	Existing
WCOG	Cascade Gateway Border Data Warehouse	Data collection and warehousing system collecting border-related transportation data from the Cascade Gateway region. Archived data used to support planning activities	Archived Data Management Subsystem	Existing

6. Needs and Services

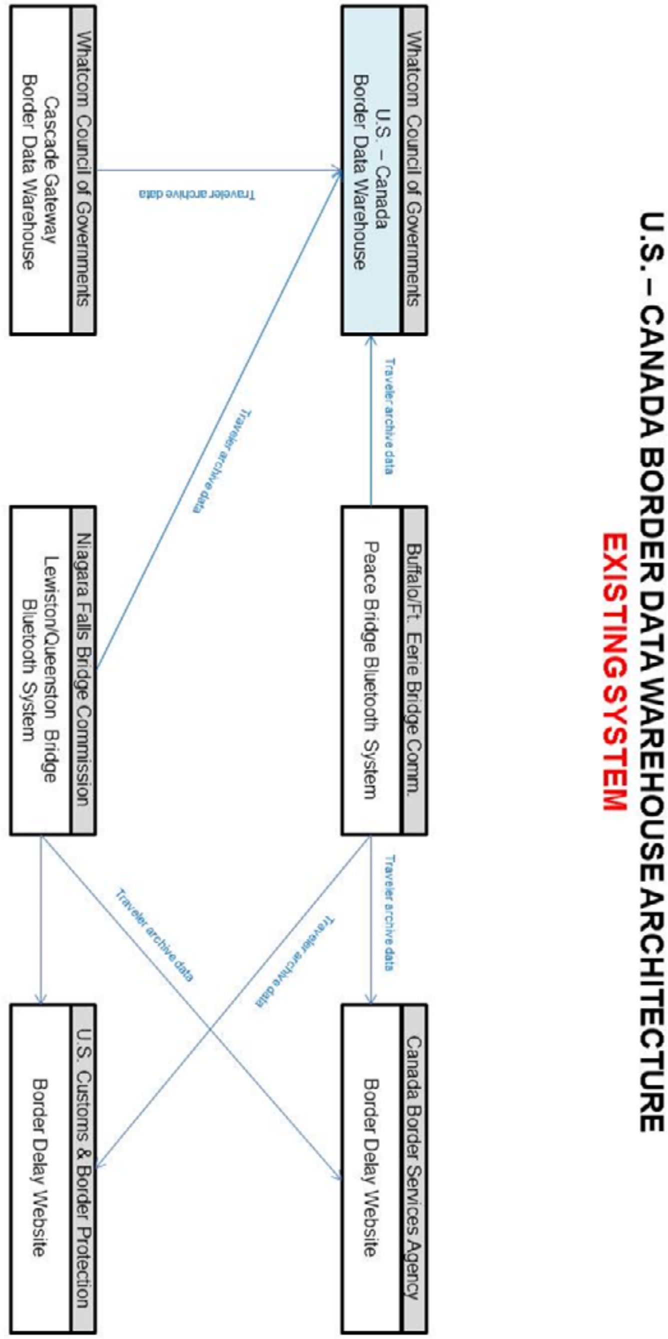
The initial needs for the project were identified in the **systems requirements** documentation. To respond to those needs, the following service areas were implemented as part of the project:

US Market Package	Canadian Market Package	Description	Elements	Status
AD2 – ITS Data Warehouse	**AD2** – Archived Data Warehouse	This market package includes collection of archived data by US or Canadian state, provincial, or regional organizations from multiple agencies and data sources spanning modal and jurisdictional boundaries. It performs the additional transformations and provides the additional meta data management features that are necessary so that all this data can be managed in a single repository with consistent formats. The potential for large volumes of varied data suggests additional on-line analysis and data mining features that are also included in this market package in addition to the basic query and reporting user access features.	Bluetooth Field Equipment; Border Data Warehouse; Cascade Gateway Border Data Warehouse; Systems Using Warehouse API; User Information Device	Existing
AD3 – ITS Virtual Data Warehouse	**AD3** – Archived Data Virtual Warehouse	This market package provides for the exchange of archive data between different archives.	Border Data Warehouse; Cascade Gateway Border Data Warehouse	Existing
ATIS1 – Broadcast Traveler Information	**ATIS1** – Broadcast Traveller Information	This market package collects traffic conditions, advisories, general public transportation, toll and parking information, incident information, roadway maintenance and construction information, air quality and weather information, and broadcasts the information to travelers using technologies such as FM subcarrier, satellite radio, cellular data broadcasts, and Internet web casts. The information may be provided directly to travelers or provided to merchants and other traveler service providers so that they can better inform their customers of travel conditions. Successful	Bluetooth Field Equipment; User Information Device	Existing

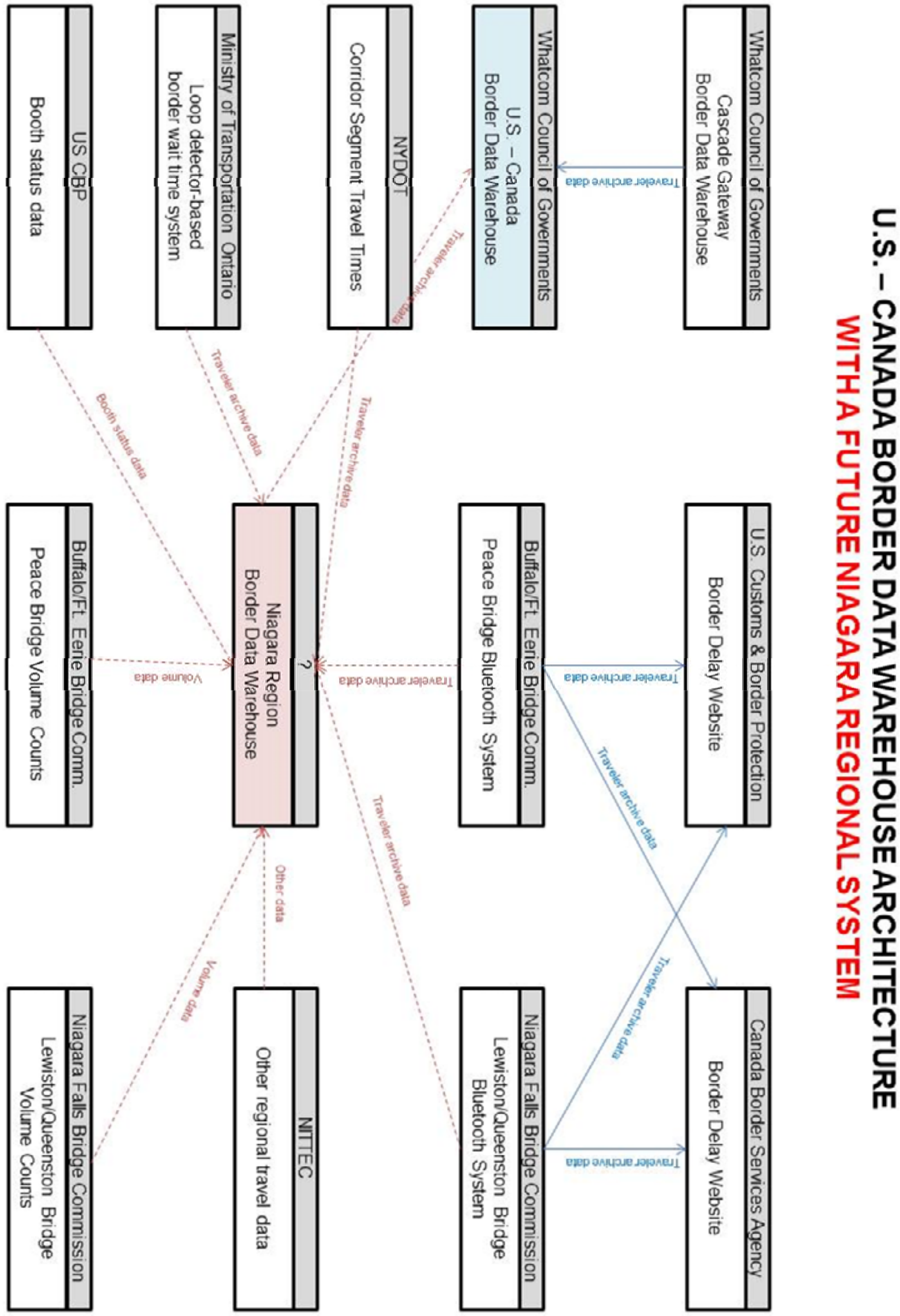
		deployment of this market package relies on availability of real-time traveler information from roadway instrumentation, probe vehicles or other sources.		

7. Interfaces and information exchanges

The following project design shows the completed project at the national level:



This graphic shows how the system would look like should the Niagara Region Border Data Warehouse get additional regional data for inclusion:



The following table illustrates the flow of information between system elements and status of that connection.

Source Element	Flow Name	Destination Element	Status
BFEPBA Bluetooth Field Equipment	Traveler archive data	Border Data Warehouse	Existing
NFBC Bluetooth Field Equipment	Traveler archive data	Border Data Warehouse	Existing
Cascade Gateway Border Data Warehouse	Traveler archive data	Border Data Warehouse	Existing
Systems Using Warehouse API	Archived data product requests	Border Data Warehouse	Existing
User Information Device	Archived data product requests	Border Data Warehouse	Existing

8. Functional Requirements

Functional requirements describe the activities performed by each ITS element within the border data warehouse project.

For this project, specific systems requirements were identified in the **Systems Requirements** document.

The following generalized requirements may also apply and come directly from U.S. National Architecture examples.

Element	Functional Area	Requirement	Status
Bluetooth Field Equipment	Virtual Data Warehouse Services	The center shall coordinate information exchange with a local data warehouse.	Existing
User Information Device	Personal Basic Information Reception	The personal traveler interface shall provide access to the data warehouse.	Existing
Cascade Gateway Border Data Warehouse	Virtual Data Warehouse Services	The center shall provide capabilities to access "in-place" data from geographically dispersed archives. These capabilities may include analysis, data fusion, or data mining.	Existing
		The center shall support the collection of archived data from other archives on an as-needed basis. (This minimizes the need to duplicate the comprehensive set of data from the remote archives in the local data warehouse.)	
		The center shall provide the local archived data schema to other archive systems.	

Element	Functional Area	Requirement	Status
Border Data Warehouse	ITS Data Repository	The center shall collect data to be archived from one or more data sources.	Existing
		The center shall store the archived data in a focused repository that is suited to a particular set of ITS data users.	Existing
		The center shall include capabilities for performing quality checks on the incoming archived data.	Existing
		The center shall include capabilities for error notification on the incoming archived data.	Existing
		The center shall include capabilities for archive to archive coordination.	Existing
		The center shall provide the capability to execute methods on the incoming data such as cleansing, summarizations, aggregations, or transformations applied to the data before it is stored in the archive.	Existing
		The center shall respond to requests from the administrator interface function to maintain the archive data.	Existing
		The center shall collect data to be archived from one or more data sources.	Existing
	Traffic and Roadside Data Archival	The center shall collect traffic sensor information from roadside devices.	Existing
	Virtual Data Warehouse Services	The center shall provide capabilities to access "in-place" data from geographically dispersed archives. These capabilities may include analysis, data fusion, or data mining.	Existing
		The center shall support the collection of archived data from other archives on an as-needed basis. (This minimizes the need to duplicate the comprehensive set of data from the remote archives in the local data warehouse.)	Existing
		The center shall provide the local archived data schema to other archive systems.	Existing

9. Standards

The BDW uses a standardized XML schema.

10. Project Sequencing

Most ITS activities under the original scope of work have been completed. The only tasks still pending relate to the Niagara Region Border Data Warehouse.

Future tasks include the following:

- Addition of future border crossing wait time systems: As additional border crossing wait time systems are installed, they will need to be added into the archive. This is the top priority for this project.

11. Agreements

Funding Agreements

- **WCOG –U.S. Federal Highway Administration**: HOFM-1: Allocation of Fiscal Year 2012 Funds for a Joint Project with Transport Canada
- **WCOG – Transport Canada**: BWT 2012-01: U.S. – Canada Border Data Warehouse Agreement

Data Sharing Agreements

- Verbal Agreement – **WCOG and Buffalo/Fort Erie Public Bridge Authority**: The bridge authority currently shares data from the Bluetooth system installed at its locations. No formal agreement is in place.
- Verbal Agreement – **WCOG and Niagara Falls Bridge Commission**: The bridge authority currently shares data from the Bluetooth system installed at its locations. No formal agreement is in place.

Operational Agreements

- **WCOG – Transport Canada, U.S. Federal Highways** – WCOG agrees to operate the BDW for a period of one year following the completion of funding March 31, 2014, as per the funding agreements listed above.

12. Architecture Maintenance

This project architecture is for the U.S. – Canada Border Data Warehouse project only. As changes are made to the archive this architecture will be updated accordingly.

The project architecture will also be incorporated into the revised Whatcom Regional ITS Architecture under development in 2014.

A copy of this project architecture has been submitted to the Niagara International Transportation Technology Coalition for consideration of inclusion in their regional ITS architecture. Copies have also been sent to stakeholder agencies involved in the B.C. ITS Strategic Plan and the Ministry of Transportation Ontario.

13. For More Information

The U.S. – Canada Border Data Warehouse is online at: www.borderdatawarehouse.com.

Project reports, appendices, and all documentation are available on the project website at: www.theimtc.com/nationalbdw.

More information is available by contacting: Melissa Fanucci, Senior Planner, Whatcom Council of Governments, at (360) 676-6974 or by email at: melissa@wcog.org.

Appendix E: System design documentation

Prepared for Whatcom Council of Governments

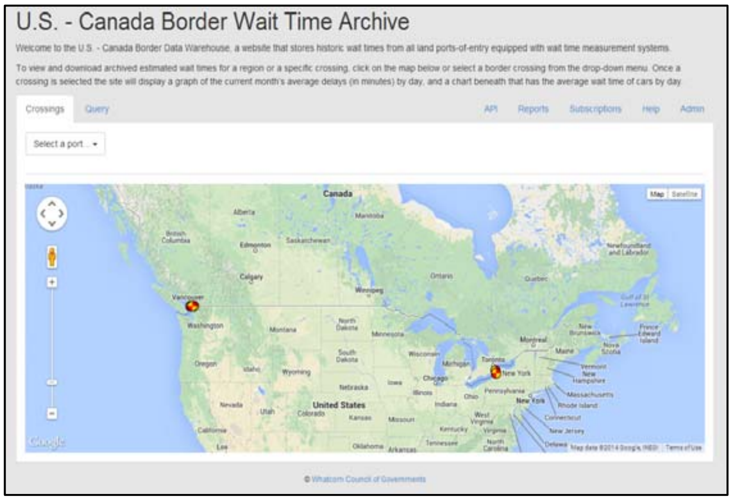
by IBI Group

CLIENT:	Whatcom Council of Governments
PROJECT NAME:	WCOG National Border Data Warehouse
REPORT TITLE:	**Error! Reference source not found.**
IBI REFERENCE:	34638
VERSION:	1.0
DIGITAL MASTER:	[File Location]
ORIGINATOR:	Tyler Lokken & Jeff Liske
REVIEWER:	Jonathan Darton
AUTHORIZATION:	Homayoun Vahidi
CIRCULATION LIST:	
HISTORY:	

IBI GROUP

1 Introduction

The National Border Data Warehouse (NBDW) is the central repository for delay data for U.S.-Canada border crossings. Currently, delay data from the Buffalo-Niagara and Cascade Gateway regions is being collected and archived. The system has been designed to capture data from the Cascade Gateway API and Buffalo Niagara - FreeAhead Inc. FTP site and can be expanded to support the collection of delay data from others regions if required in the future.



The NBDW platform provides the tools, applications, and resources necessary for carrying out warehouse operations, including data integration, web-based reporting & querying functionality, subscription management, and maintenance activities.

This document describes the architecture and functionality of the NBDW system and should be used as a reference for any future enhancements or support activities.

2 System Overview

The following sections provide an overview of the NDBW system including the software and software architecture components.

2.1 Software Architecture

The software architecture for the NBDW system, as outlined in figure 1, consists of four different tiers:

1. User – consists of users accessing the web interface using various web browsers.
2. Web – the web application including user interface (UI) and API components.
3. Database – the storage mechanism for all collected delay data and dynamic configuration components that are managed by the admin interface (i.e. subscriptions).
4. Application – consists of the Data Collection Service responsible for gathering data from Cascade Gateway and Buffalo Niagara data sources, the Glacier Backup Service that is responsible for archiving database backups to

Amazon Glacier, and the Utility Console Application that is used for maintenance activities.

The following diagram provides an overview of the NBDW software architecture and the flow of information between the various software interfaces.

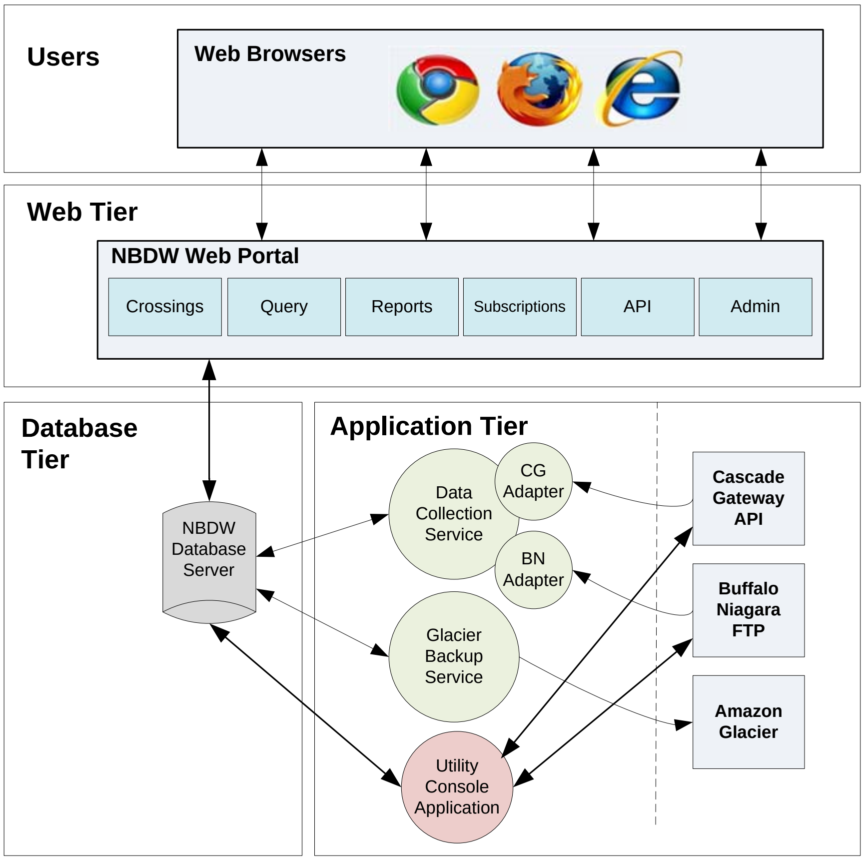


Figure 1- Software Architecture

The following sections provide a description of the major components of the software architecture.

2.1.1 Web Portal

The web portal is the front end to the NBDW system that provides tools for report generation, an API for systematic access to data, subscriptions, and more. More detailed descriptions of the functionality supported by the Web Portal can be found in section 3 of this document.

There are two access levels that determine available functionality: public and administrator-only. Administrator-only privileges are required to manage website content, view logs, and configure various aspects of the system.

The web application is built on Microsoft's MVC4 framework. The user interfaces makes use of modern presentation frameworks including Bootstrap, jQuery, and AngularJS.

2.1.2 Data Collection Service

The Data Collection Service is an application that provides a variety of services, including data integration, subscription notifications, and health status checks. Any maintenance tasks that must be performed at certain intervals are initiated by this application.

The application has integrated adapters to support data collection activities from both Buffalo-Niagara (Bluetooth data accessed via FTP) and the Cascade Gateway API. Additional data sources, if using the same source structure as Buffalo-Niagara or Cascade Gateway, can be integrated by using the same adapters.

This application can be run as a standalone executable to assist with debugging or bundled into a managed Windows service.

2.1.3 Glacier Backup Service

The Glacier Backup Service is an application that is used to manage the storage and retention of database backups in the Amazon Glacier cloud. This offsite storage solution offers protection against data loss.

The basic idea behind the application is that a target directory containing database backups will be scanned daily for new items; any new items are uploaded to the Glacier cloud and kept for a period of twenty days.

This application does not link to the shared library (as described in section 2.1.5) that was used to develop the applications – it is self-contained by design so that it can be reused in other WCOG projects without carrying the NBDW shared library as a dependency.

2.1.4 Utility Console Application

The Utility Console is a menu-driven command line application that is used to backfill missing data, perform data integrity checks, and to generate passwords for administrator accounts.

2.1.5 Shared Library

All applications described in the previous sections, with the exception of the Glacier Backup Service, utilize a shared library which allows applications to reuse common code and benefit from enhancements.

The library provides a suite of tools and utilities, including time-related functions, system action abstractions, and object models. Perhaps the most critical part of the library is the Query and its related structures. The Query is interpreted by data source adapters for essential warehouse operations like integrating data, executing queries, and backfilling data.

2.2 Hardware Architecture

The NBDW Hardware Architecture, as outlined in figure 2, consists of server infrastructure that is hosted using Amazon Web Services (AWS). The following sections describe the hardware architecture and Amazon AWS components of the NBDW system.

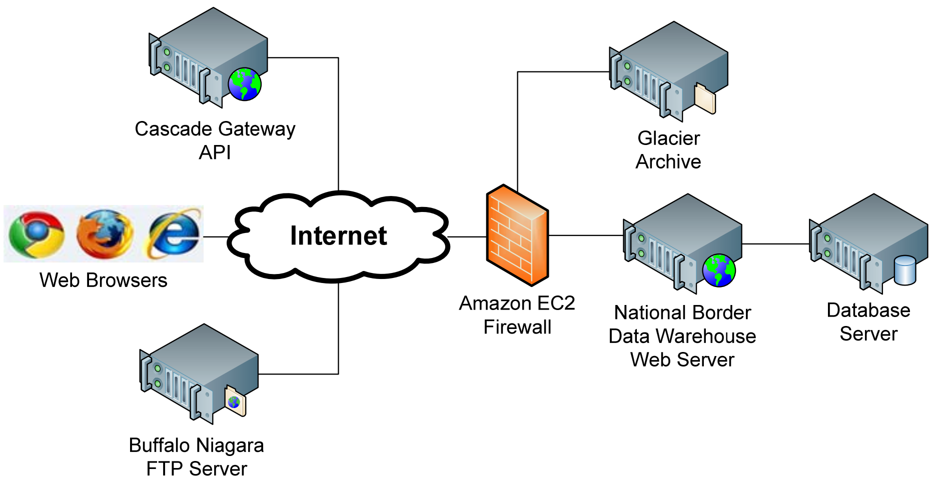


Figure 2 - Hardware Architecture

2.2.1 Amazon EC2

Amazon EC2 is a cloud based virtual server environment that is used for both NBDW Web and Database servers. The following sections describe the configuration of the Web and Database servers.

2.2.1.1 NBDW Web Server

The NBDW Web Server has the following configuration.

Operating System	Windows Server 2008 R2 Datacenter SP1
Instance Type	m1.medium
Private IP	10.252.73.158
Public IP	54.244.245.227
Availability Zone	us-west-2a
Public DNS	ec2-54-244-245-227.us-west-2.compute.amazonaws.com
Web Server	IIS 7
Microsoft .NET	v4

2.2.1.2 Database Server

The Database Server has the following configuration.

Operating System	Windows Server 2008 R2 Datacenter SP1

Instance Type	m1.medium
Private IP	10.252.143.38
Public IP	54.244.133.145
Availability Zone	us-west-2a
Public DNS	ec2-54-244-133-145.us-west-2.compute.amazonaws.com
SQL Server	Microsoft SQL Server 2008

2.2.2 Amazon Email Sending Service (SES)

Amazon SES is used for sending email notifications from the NBDW System including daily system health status information and email subscriptions. The configured email address used to send email is: donotreply@borderdatawarehouse.com.

2.2.3 Amazon Glacier

Amazon Glacier is a cloud based archive and file storage service that is used to store offsite backups for the NBDW system. See section 2.1.3 for more information.

3 Web Portal Features & Functionality

The following sections provide an overview of the features available to users of the NBDW Web Portal.

3.1 User Interface (UI)

3.1.1 Crossings Map

The Crossings Map displays the locations of currently defined crossings and crossing directions. The Crossings are available at lower zoom levels and are depicted on the map in the screenshot below. The user can click on a map marker or select a port from the drop down to view data for a particular crossing direction.

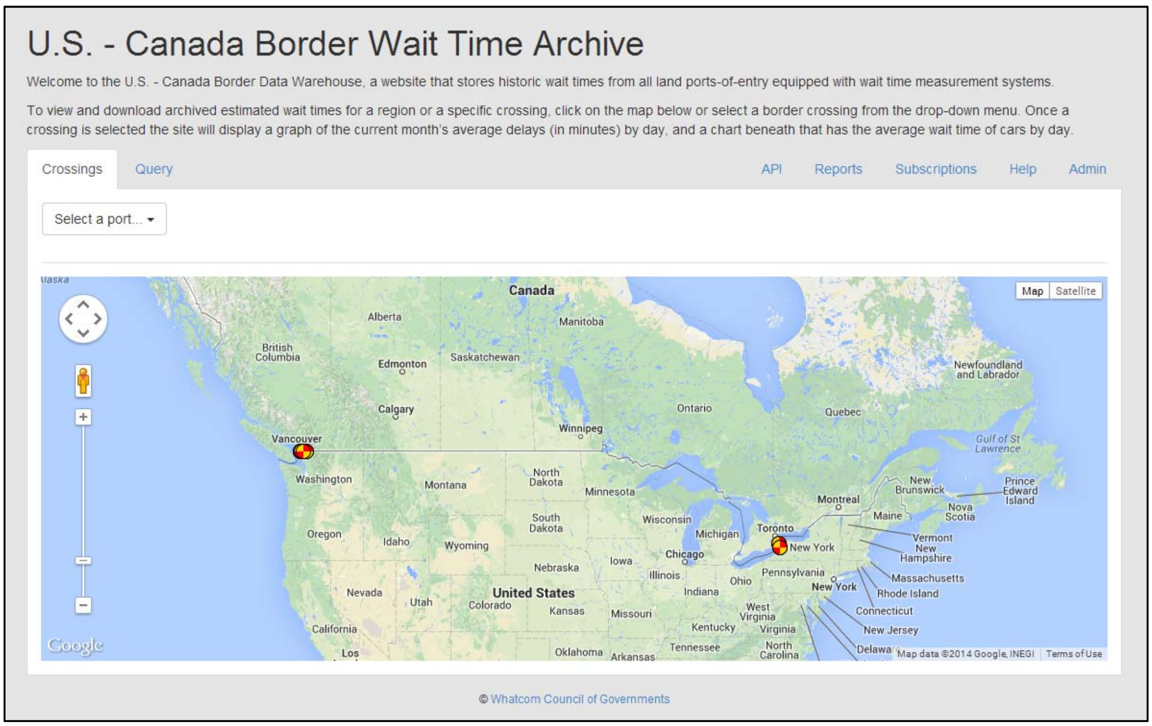


Figure 3 - Crossings Map

3.1.2 Crossing Data – Chart and Calendar View

The user can select a Crossing, Year, Month, Day as well as vehicle type and metric.

The Chart has the timeframe along the X axis with the average delay (in minutes) along the Y axis.

The Calendar depicts the average delay for a selected crossing using a calendar view for either the annual or month view. The calendar view displays the average delay as well as the data availability for the selected month or day. The data availability is calculated based on the percentage of all the records for a specific time period. For a specific day there are 288 total values and the percentage is based on how many of those values were collected.

Note: the legend for the data availability applies to the calendar view, not the chart view.

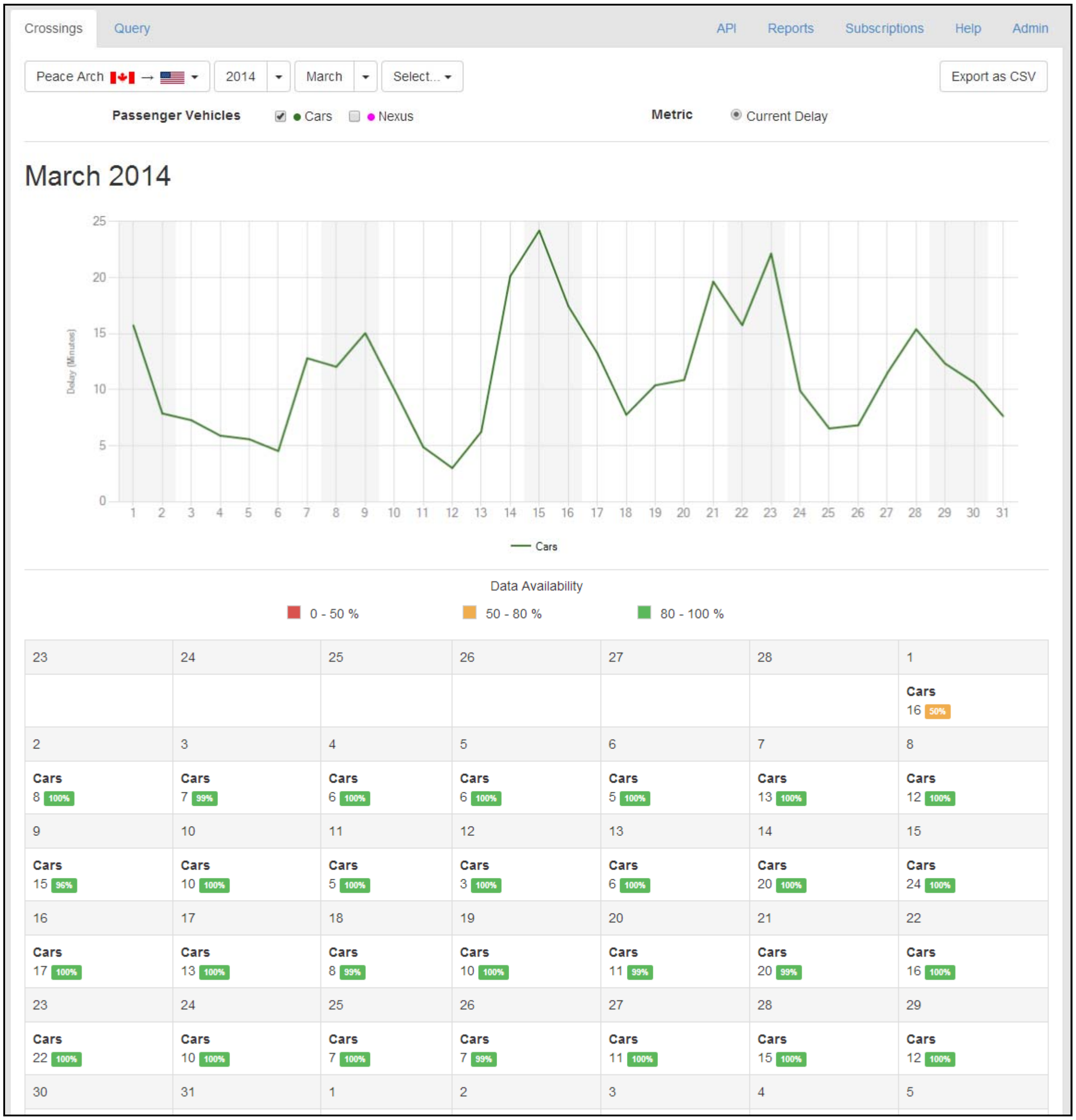


Figure 4 - Crossing Data Chart & Calendar View

3.1.3 Crossing Data – Chart and Table View

The user can drill down to aday view by clicking on a day with the top selector or clicking on a day in the calendar. The delay data at the lowest granularity is measured in 5 minute intervals.

The data is depicted in a table with striped rows and is sorted in ascending order by time.

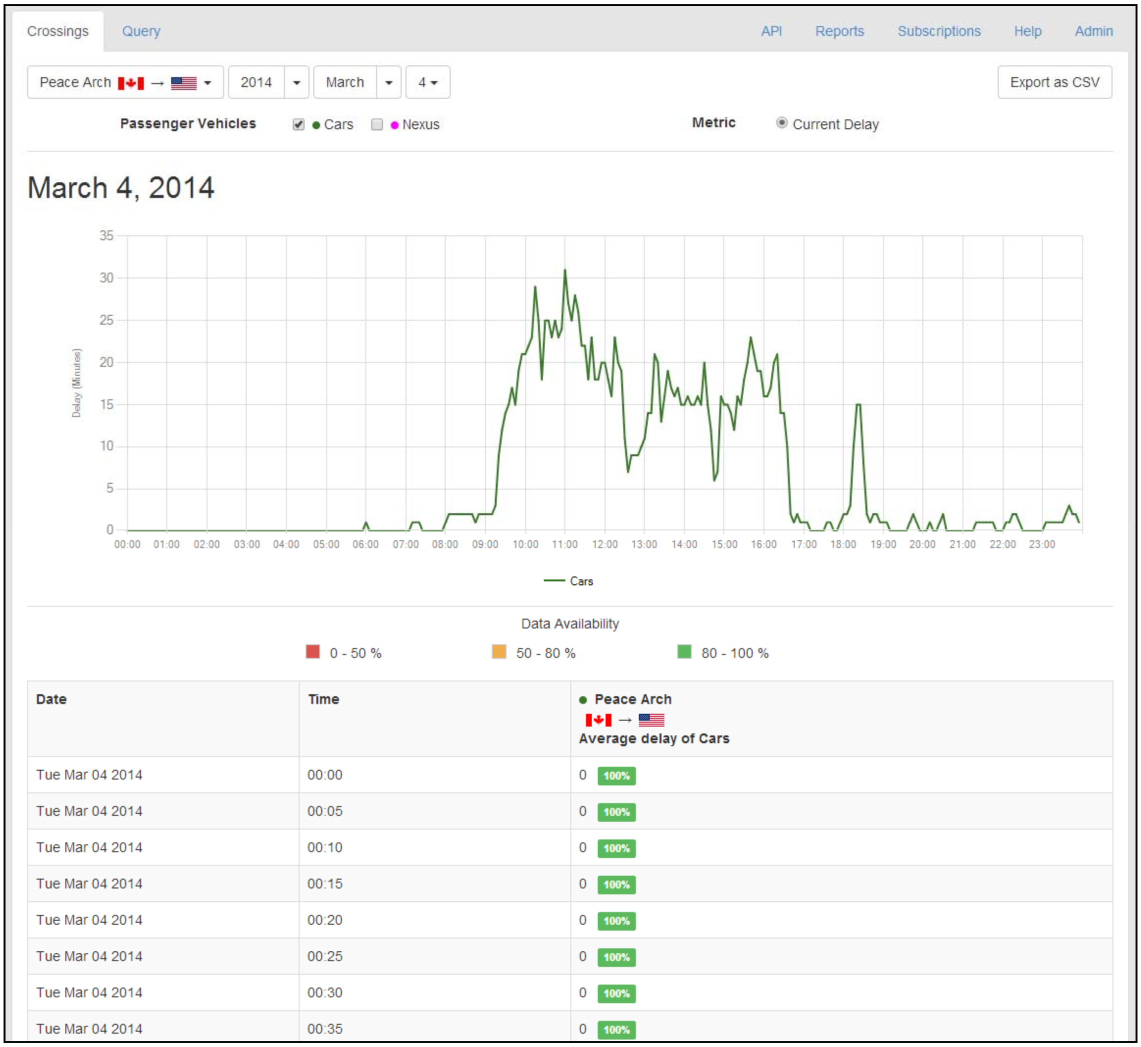
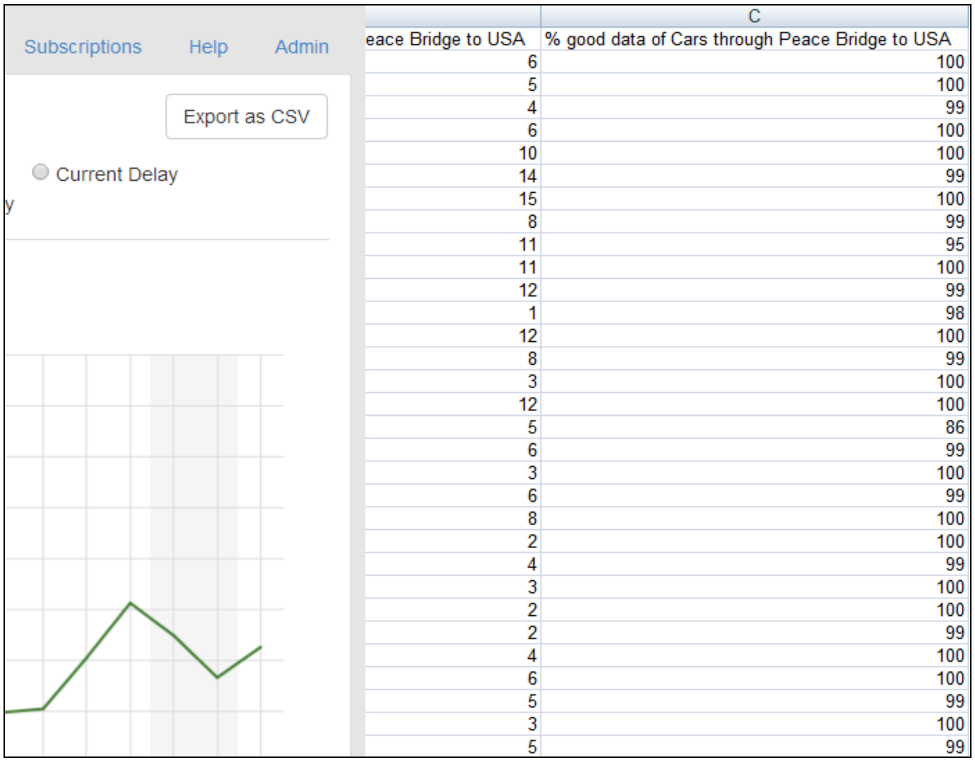


Figure 5 - Crossing Data Chart & Table View

3.1.4 Crossing Data – CSV Export

While navigating through the Crossings area of the system, the user has the ability to export data to CSV by selecting the “Export as CSV”. Associated delay and data availability values are included in the exported data by default.



eace Bridge to USA	% good data of Cars through Peace Bridge to USA
6	100
5	100
4	99
6	100
10	100
14	99
15	100
8	99
11	95
11	100
12	99
1	98
12	100
8	99
3	100
12	100
5	86
6	99
3	100
6	99
8	100
2	100
4	99
3	100
2	100
2	99
4	100
6	100
5	99
3	100
5	99

Figure 6 - Crossing Data CSV Export

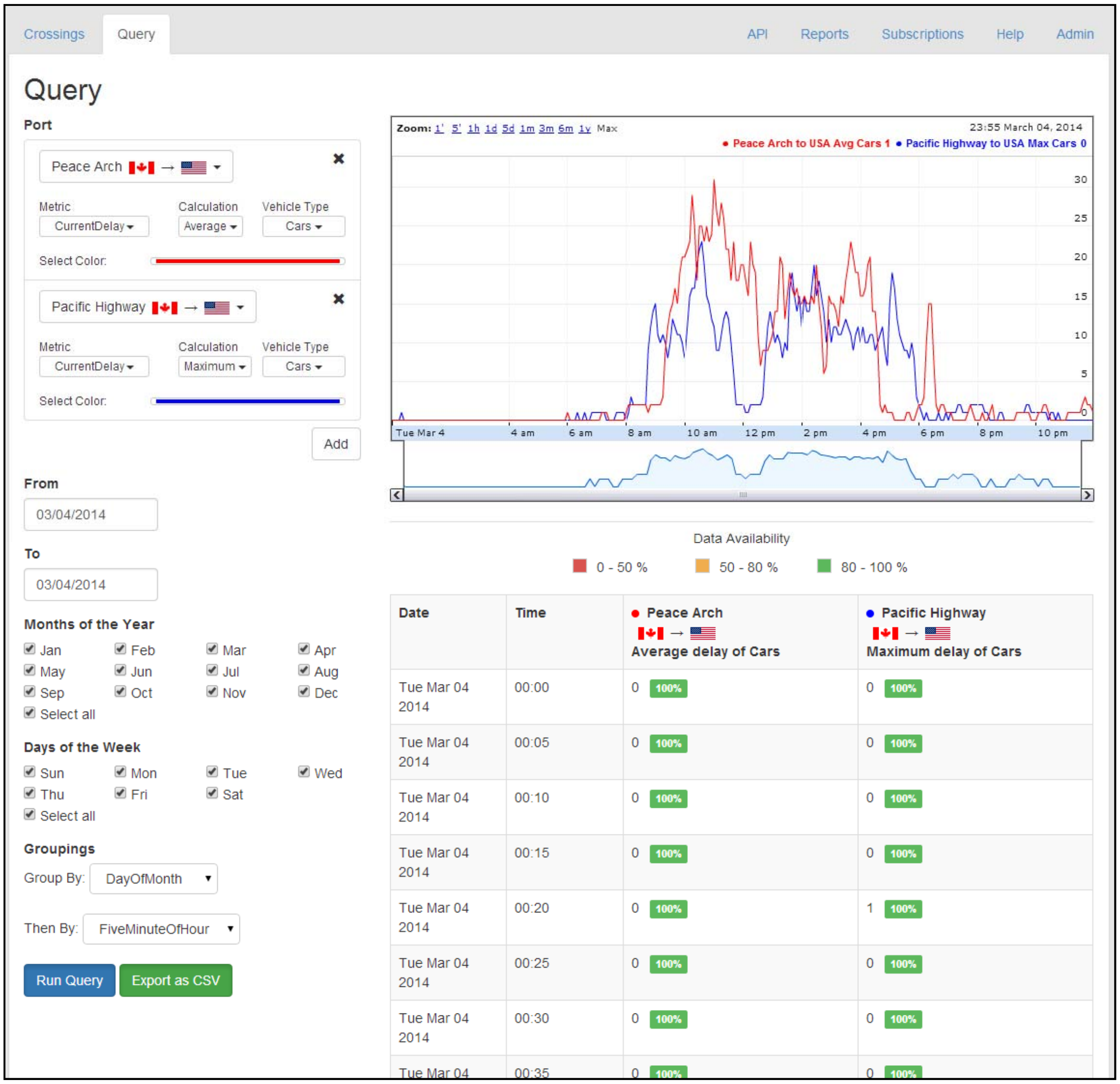
3.1.5 Query Data – Input and Output

The Custom Query capability allows users of the site to create complicated queries for crossing data. The following describes the input parameters for the custom query:

- Port – the port selection allows for any number of crossing data points and for each crossing the metric, vehicle type and calculations (average, min, max, standard deviation and variance). The user can also choose a color for the line on the chart. The Add button is used for additional crossings.
- From / To Date – the start/end date selectors allow for the selection of the time interval for the query.
- Months of Year Filter – the filter allows only certain months to be included in the results (default – all selected).
- Days of Week Filter – the filter allows only certain days to be included in the results (default – all selected).
- Group By – the Group By aggregation allows the user to group by Day, Day of Week, Month, and Year.
- Then By – the Then By aggregation allows for a sub grouping within the Group By clause, allowing for Five Minute, Hour, AM/PM, and Day.

Once the user has selected a port, they can choose to Run Query or Export to CSV.

The Chart represents the same data as the Table View, but it uses the Google visualization API and depicts the data in form of a chart. The chart has the timeframe along the X axis with the selected data points along the Y axis. The chart also allows the user to change the timeframe by shrinking it using the slider below the chart or changing it via the provided Zoom Levels (1’, 5’, 1h, etc). The chart also allows the user to interact with the chart by hovering with the mouse over any data point.



Date	Time	Peace Arch 🇨🇦 → 🇺🇸 Average delay of Cars	Pacific Highway 🇨🇦 → 🇺🇸 Maximum delay of Cars
Tue Mar 04 2014	00:00	0 100%	0 100%
Tue Mar 04 2014	00:05	0 100%	0 100%
Tue Mar 04 2014	00:10	0 100%	0 100%
Tue Mar 04 2014	00:15	0 100%	0 100%
Tue Mar 04 2014	00:20	0 100%	1 100%
Tue Mar 04 2014	00:25	0 100%	0 100%
Tue Mar 04 2014	00:30	0 100%	0 100%
Tue Mar 04	00:35	0 100%	0 100%

Figure 7 - Query Data Input & Output

3.1.6 Reports

The Reports area allows the public users quick access to saved reports. Reports can be created and made available to the public by an administrator. Each of the reports is a saved custom query. The user can click on the link and view the results the same way as the custom query.

Figure 8 - Reports

3.1.7 Subscriptions

The Subscription page allows for the public users to receive notification reports via email. The reports are available to the users for any crossing where the delay at the crossing exceeds a value defined by the user. The user also has the ability to choose from 2 notification types as can be seen in the screenshot below. These notification types include:

- Daily – receive a daily email for a specific Crossing where the delay exceeded the minimum threshold.
- Choose an Interval – receive an email based on an interval (hourly) every time the delay exceeds the minimum threshold.

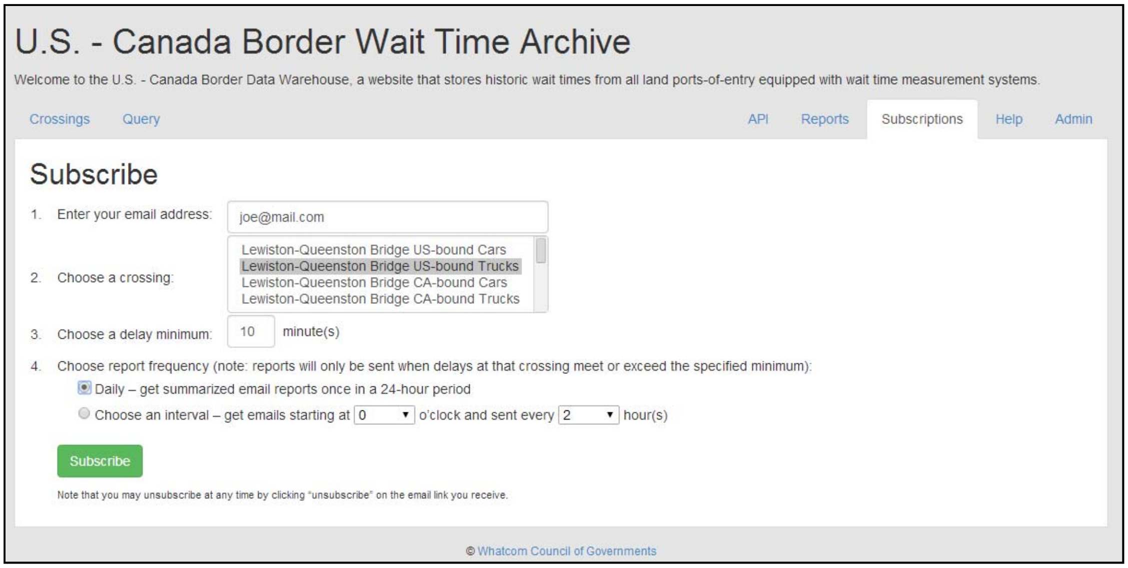


Figure 9 - Subscriptions

3.1.8 API

The API section of the Web Portal provides an overview of the National Border Data Warehouse Developer API. The page acts as a resource to any developer that would like information regarding how the warehouse can be queried for data. The API provides the users quick and easy to understand examples about how queries can be formed and executed.

The following sections outline the attributes that can be used to query the NBDW API.

3.1.8.1 Crossing

A crossing is a border crossing and can be queried for both directions or by a single direction. A crossing can be queried using query string parameters in the format of:

/Query/?series=Avg!PeaceBridgeToUsa_Cars!FF0000!CurrentDelay&start=2014-01-31&end=2014-01-31&groupings=DF&monthsOfYear=All&daysOfWeek=All&format=json

The following crossing values can be used:

- "PeaceBridgeToCanada" - Peace Bridge Northbound;
- "PeaceBridgeToUsa" - Peace Bridge Southbound;
- "LewistonQueenstonBridgeToCanada" - Lewiston-Queenston Bridge Northbound;
- "LewistonQueenstonBridgeToUsa" - Lewiston-Queenston Bridge Southbound;
- "paToCanada" - Peace Arch Northbound;
- "paToUsa" - Peace Arch Southbound;
- "phToCanada" - Pacific Highway Northbound;

- "phToUsa" - Pacific Highway Southbound;
- "laToCanada" - Lynden/Aldergrove Northbound;
- "laToUsa" - Lynden/Aldergrove Southbound;
- "shToCanada" - Sumas/Huntingdon Northbound; and
- "shToUsa" - Sumas/Huntingdon Southbound.

Example 1:

Average Delay between Jan 1-2014 and Jan 7-2014 for "PeaceBridgeToCanada". Prepare JSON-formatted response:

/Query/?series=Avg!PeaceBridgeToCanada_Cars!FF0000!CurrentDelay&start=2014-01-01&end=2014-01-07&groupings=DF&monthsOfYear=All&daysOfWeek=All&format=json

Example 2:

Average Delay between Jan 1-2014 and Mar 7-2014 for "LewistonQueenstonBridgeToUsa". Group results by day-of-the-week. Prepare JSON-formatted response.

/Query/?series=Avg!LewistonQueenstonBridgeToUsa_Cars!FF0000!CurrentDelay&start=2014-01-01&end=2014-01-07&groupings=WF&monthsOfYear=All&daysOfWeek=All&format=json

3.1.8.2 Series

The series parameter contains crossings and associated metrics, calculations, and vehicle type values separated by the "!" character. Additional crossings can be added to the series separated by a comma ",".

series=<calculation>!<crossing>_<vehicle type>!<line colour>!<metric>

The following calculations can be used:

- Avg - Average;
- Min - Minimum;
- Max - Maximum;
- StDev - Standard Deviation; and
- Var - Variance;

The following vehicle types can be used:

- Bus;
- Cars;
- FAST;
- Nexus; and
- Trucks.

Crossings in the Buffalo-Niagara region support the following delay metrics:

- ActualDelay;
- CurrentDelay; and
- PredictedDelay.

Cascade Gateway region crossings only support the "CurrentDelay" metric.

3.1.8.3 Start

The date to use for the start of the query (inclusive). The start date must be in the format: yyyy-mm-dd.

3.1.8.4 End

The date to use for the end of the query (inclusive). The end date must be in the format: yyyy-mm-dd.

3.1.8.5 Groupings

The following groupings for the query can be used:

- "D" - DayOfMonth
- "W" - DayOfWeek;
- "M" - MonthOfYear;
- "Y" - Year;
- "F" - FiveMinuteOfHour;
- "H" - HourOfDay; and
- "A" - AmPm;

3.1.8.6 MonthsOfYear

The following months of year can be used separated by commas:

- All;
- Jan;
- Feb;
- Mar;
- Apr;
- May;
- Jun;
- Jul;
- Aug;

- Sep;
- Oct;
- Nov; and
- Dec.

3.1.8.7 DaysOfWeek

The query can be limited to certain days of the week by using a combination of the following values separated by commas:

- All;
- Sun;
- Mon;
- Tue;
- Wed;
- Thu;
- Fri; and
- Sat.

3.1.8.8 Format

For API requests the format parameter should be set to "json" or "csv".

3.1.9 Login

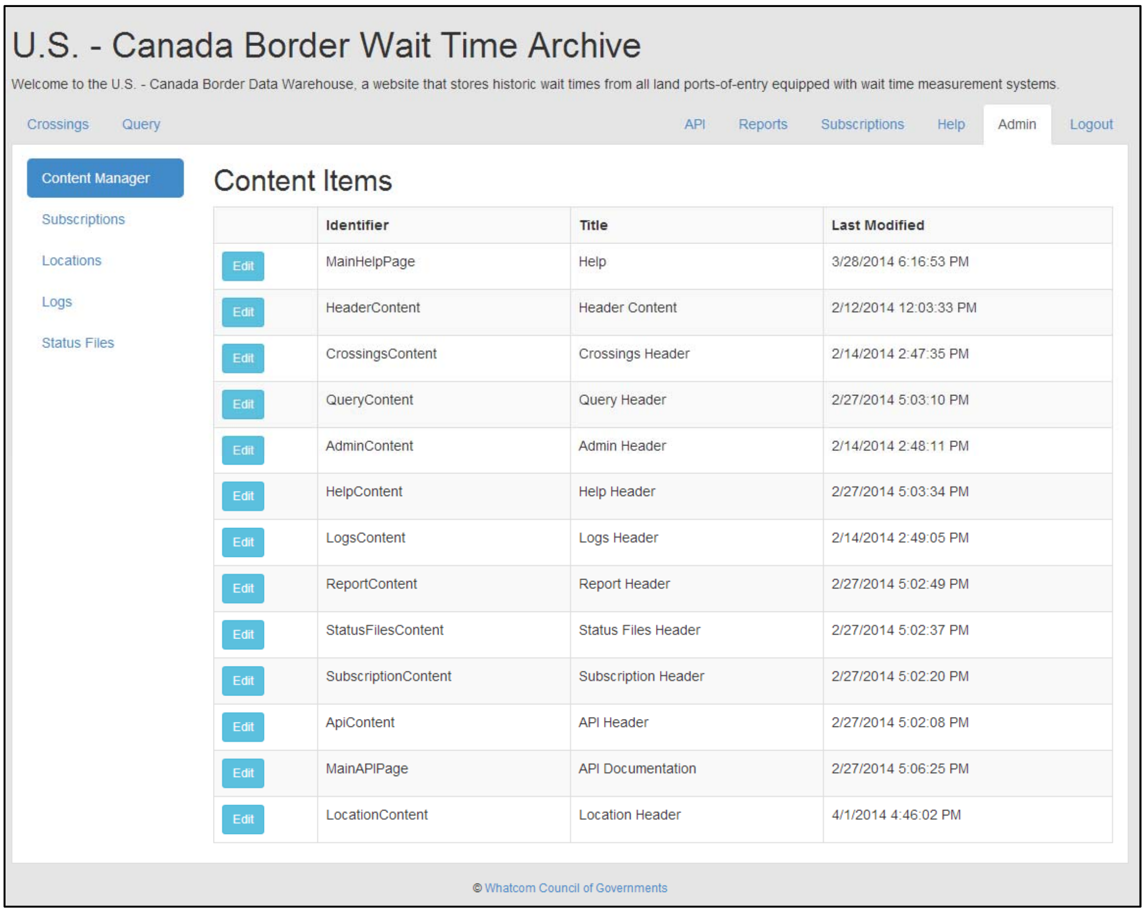
The Login page for the site is available at www.borderdatawarehouse.com/Admin. The login secures the administration area from the public sections of the site. The validation of the username and password is performed against the database where the username and password are securely stored.

3.2 Site Administration

The admin section of the NBDW Web Portal allows for dynamic content and configurations to be managed by and authenticated admin user.

3.2.1 Content Management

Administrators can manage content for specific sections of the website, including the help page, contextual help, API documentation, and more. Content can be added and managed using the integrated "What You See Is What You Get" (WYSIWYG) editor and can also be edited in HTML format.



	Identifier	Title	Last Modified
Edit	MainHelpPage	Help	3/28/2014 6:16:53 PM
Edit	HeaderContent	Header Content	2/12/2014 12:03:33 PM
Edit	CrossingsContent	Crossings Header	2/14/2014 2:47:35 PM
Edit	QueryContent	Query Header	2/27/2014 5:03:10 PM
Edit	AdminContent	Admin Header	2/14/2014 2:48:11 PM
Edit	HelpContent	Help Header	2/27/2014 5:03:34 PM
Edit	LogsContent	Logs Header	2/14/2014 2:49:05 PM
Edit	ReportContent	Report Header	2/27/2014 5:02:49 PM
Edit	StatusFilesContent	Status Files Header	2/27/2014 5:02:37 PM
Edit	SubscriptionContent	Subscription Header	2/27/2014 5:02:20 PM
Edit	ApiContent	API Header	2/27/2014 5:02:08 PM
Edit	MainAPIPage	API Documentation	2/27/2014 5:06:25 PM
Edit	LocationContent	Location Header	4/1/2014 4:46:02 PM

Figure 10 - Content Management

Item descriptions:

MainHelpPage – all help content organized into linkable sections with HTML anchors

HeaderContent – the content of the top header

MainAPIPage – the API developer documentation

*[*Page*]Content* – every page has its own description content that sits just below the top header

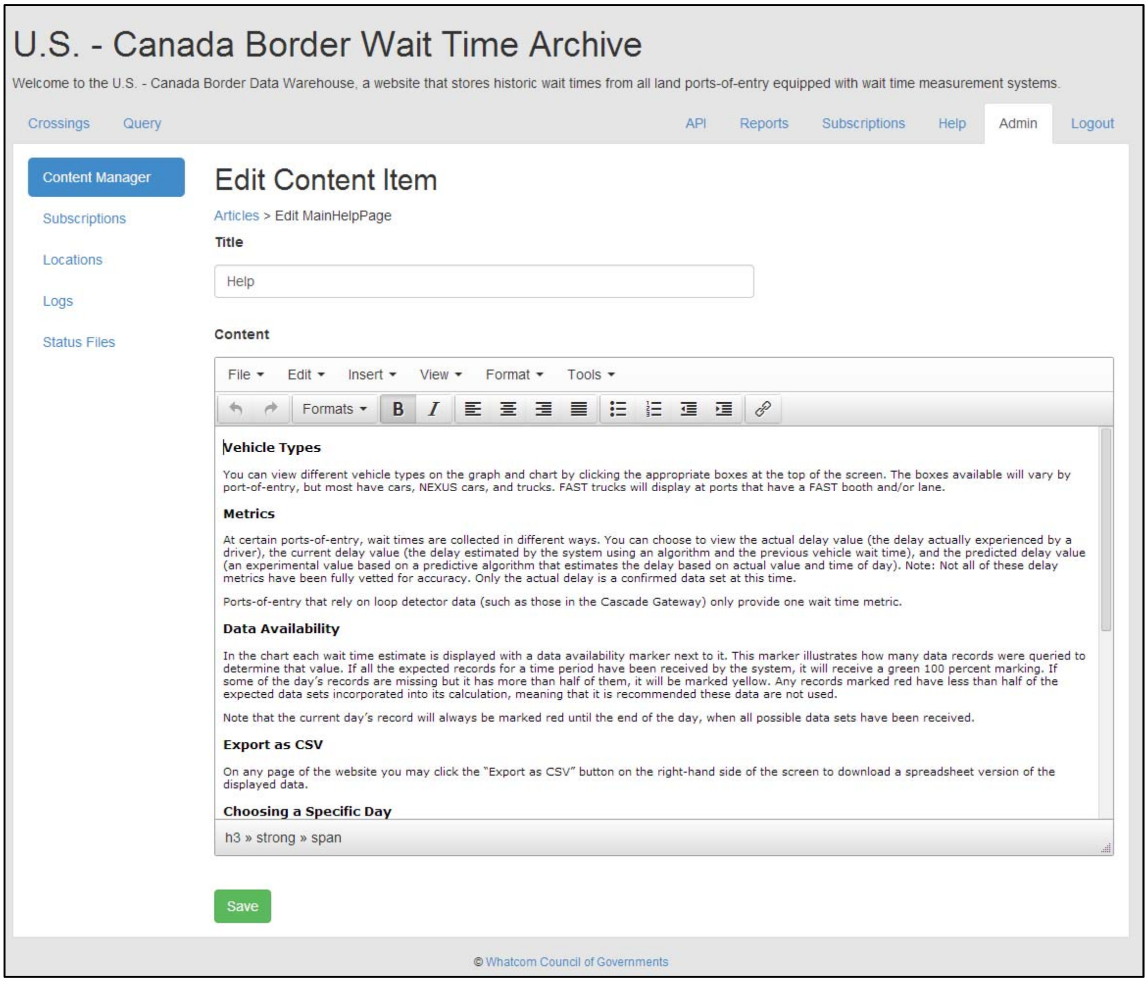


Figure 11 - Edit Content - WYSIWYG Editor

3.2.2 Reports Admin

The administration of Reports requires the administrator to save and name a custom query. The query will be made available to public users.

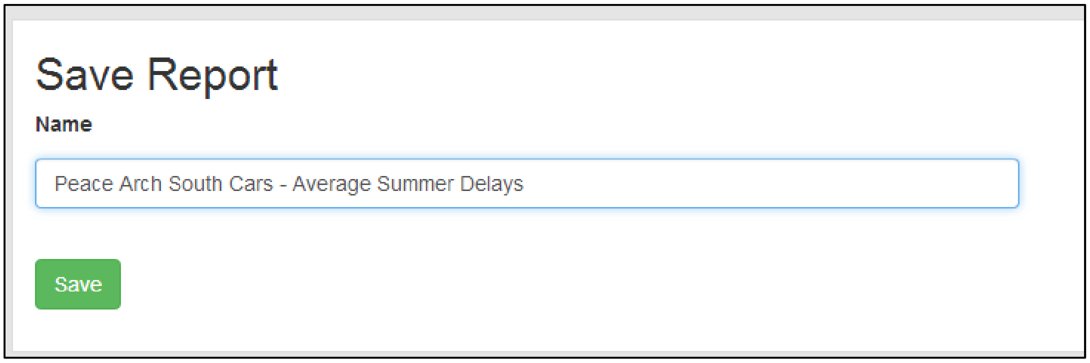


Figure 12 - Save Report

Existing reports can be deleted from the site by the administrator by clicking delete when authenticated.

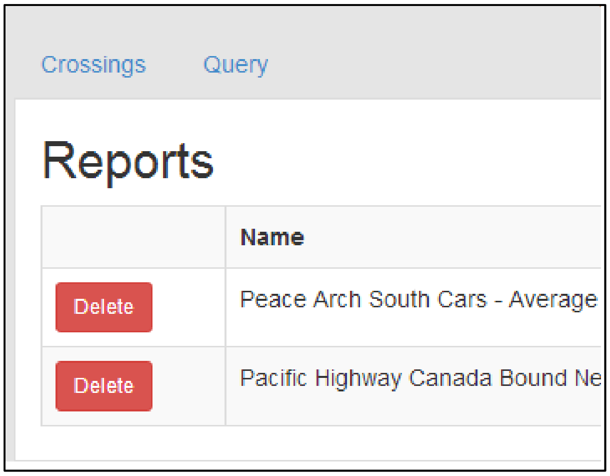


Figure 13 - Delete Report

3.2.3 Subscriptions Admin

The management of subscriptions can be performed in the admin section of the system where existing subscriptions can be edited or deleted.

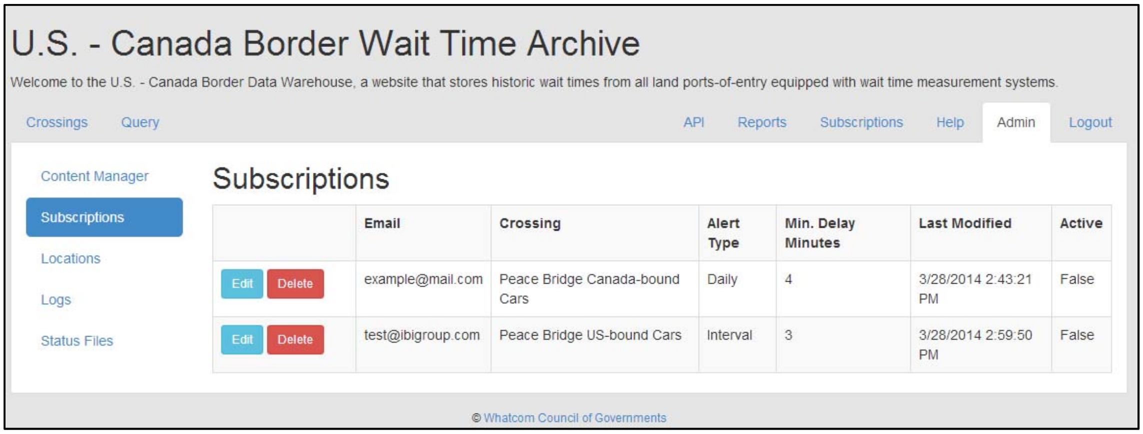


Figure 14 - Manage Subscriptions

3.2.4 Crossing Locations

The latitude and longitude coordinates of crossing lane locations can be managed in the Locations section of the admin interface.

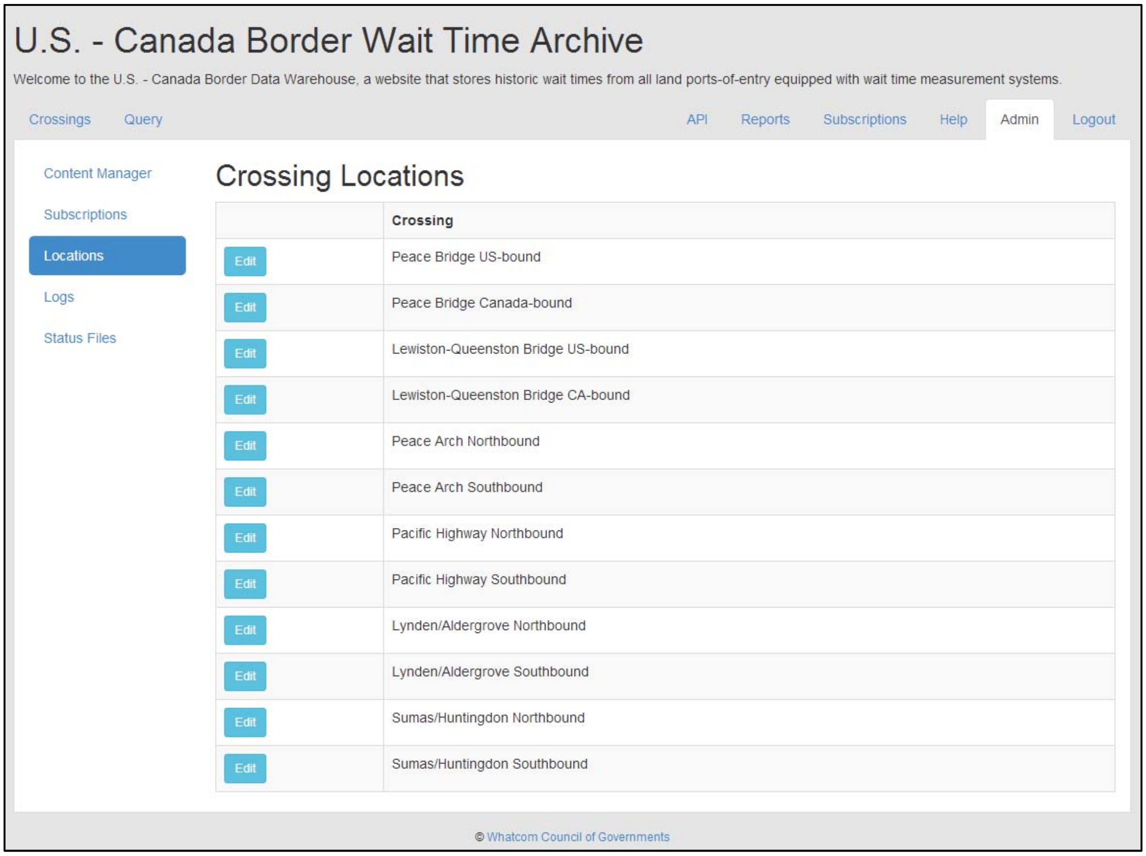


Figure 15 - Crossing Locations

The admin user can also use the map to configure the location of the crossing. The icon on the map can be dragged-and-dropped to a desired location. The latitude and longitude fields are automatically updated as the user moves the icon.

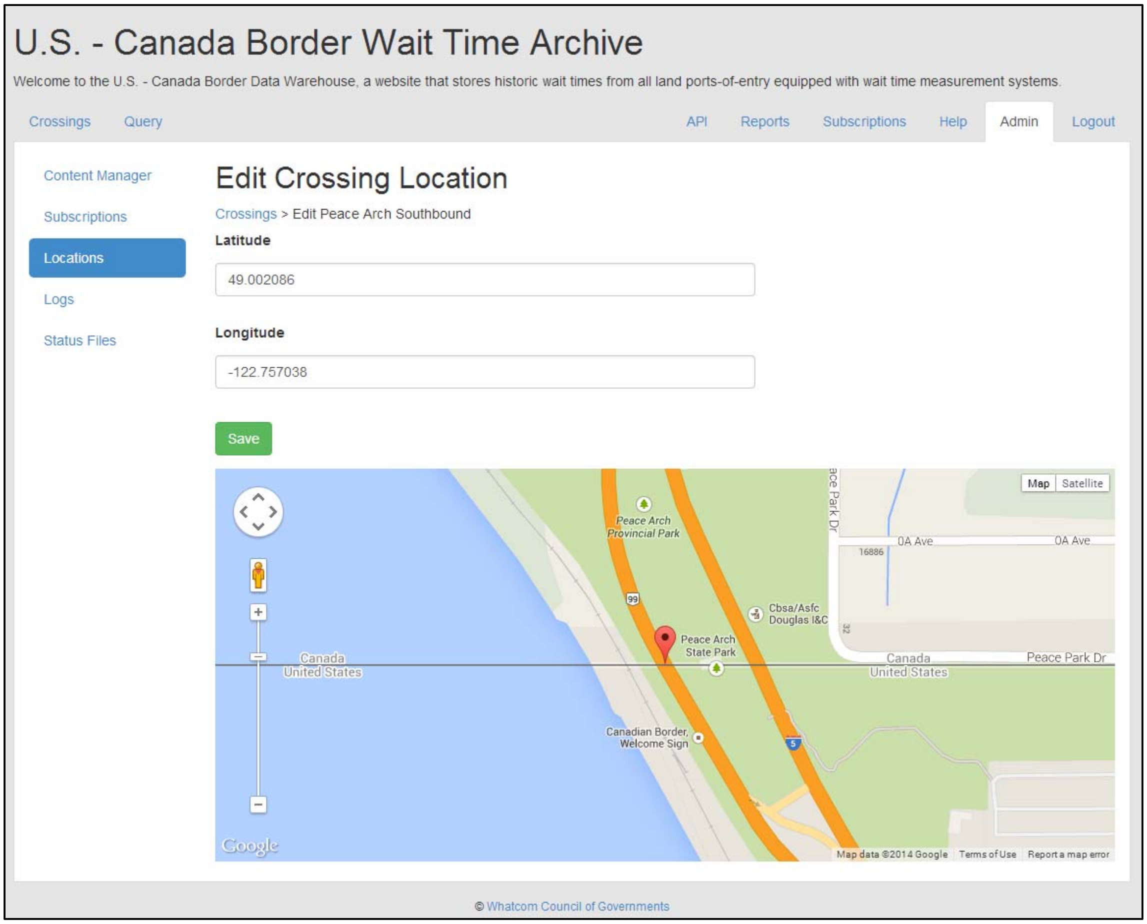


Figure 16 - Manage Crossing Coordinates

3.2.5 Logs

The admin user can view logs from the collector console in Logs section of the admin interface. Issues associated with Data Collection Service connectivity to external data sources can be assessed using the information captured in the log table.

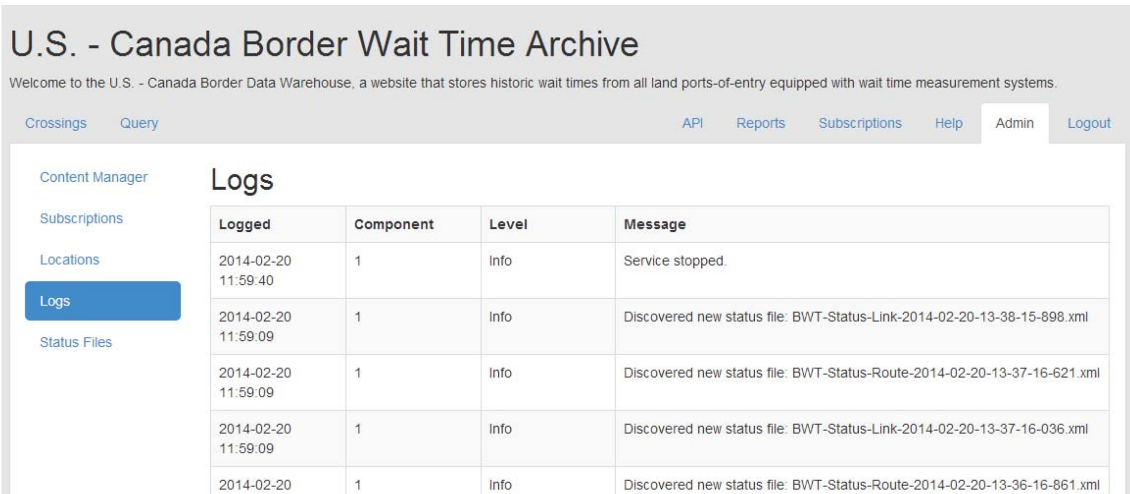


Figure 17 - Logs

3.2.6 Status Files

The status files section in the admin interface can be used to view the status of data captured from the Buffalo-Niagara FreeAhead Inc. FTP site.

4 Data Integration

The integration of data from multiple sources is an essential feature of the NBDW. This section describes how the challenges of data integration were handled using adapters and provides some details on the specific adapters for two regions using different technologies.

4.1 Data Source Adapters

Data source adapters are software modules that expose a common interface for client software while encapsulating the complexity of individual data sources. Each module provides a concrete implementation of the abstract class *DataSourceAdapter* as well as an implementation of the *DataSourceRepository* class.

Every implementation of a DataSourceAdapter must provide a unique id and name, a human-friendly name, and a function that retrieves the UTC offset. The unique id and name both represent the adapter in the database configuration and data tables, whereas the human-friendly name is suitable for display in front end systems. The function that retrieves the UTC offset maps a provided date/time value to the UTC offset local to the adapter using the time-related utilities of the DataSourceAdapter class.

Every implementation of a DataSourceRepository must provide two methods – one to retrieve the relevant implementation of DataSourceAdapter and the other to interpret the Query object and return results.

4.2 Cascade Gateway API Adapter

The Cascade Gateway Border Data Warehouse is a central repository of traffic-related data for British Columbia-Washington border crossings. The system collects data from ATIS systems within the region and provides an online reporting interface for querying crossing metrics along with WIM, detector, and BTS freight data. The Cascade Gateway API adapter connects to the Cascade Gateway API to a obtain delay data.

4.3 Buffalo-Niagara Bluetooth Adapter

The Buffalo-Niagara Bluetooth adapter utilizes local database tables populated by the Collector Console to a obtain delay data that is then formally available in the NBDW.

4.4 Data Source Configuration

The integration system was designed to allow administrators to choose which data sources will be used by the Web Portal. This configuration option is necessary to use the same system for both National and Buffalo-Niagara specific Web Portals.

4.5 Common Container

The destination for integrated data is the common container provided by the IntegratedAdapterData fact table. This table is composed of a number of fields that allow for queries to be performed across dimensions that identify the values in space, time, and other characteristics.

5 Database Design

This section elaborates on some data modeling decisions and provides a detailed explanation of the database. Note that the set of tables related to the Buffalo-Niagara data source is documented separately; while these tables are certainly part of the production database, they are specific to the BuffaloNiagaraBluetooth adapter which is independent of the operation of the NBDW and could be removed if the adapter was replaced or discontinued.

5.1 Crossing and Data Source Configuration

Configuration of crossings and their characteristics is required before data can be integrated into the warehouse. Below is a diagram that outlines the database structures that are related to this initial configuration.

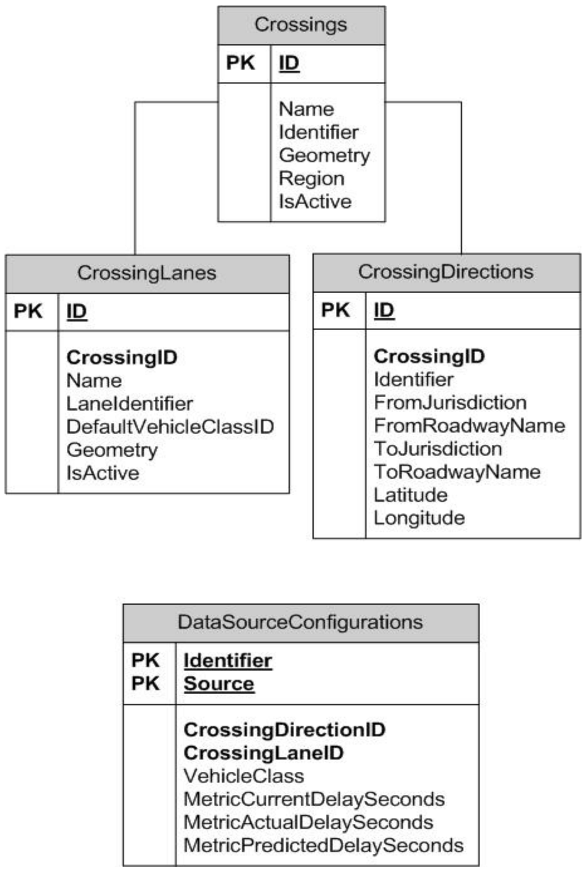


Figure 18 - Data Source Configuration

Note that Vehicle Class stores software-defined values. See section 5.5 for more information on these values.

5.2 Crossing Lane and Crossing Direction

Crossing lanes and crossing directions are decoupled so as to allow for references to each distinct dimension in fact tables. This distinction is important for fact tables compatible with reversible lane scenarios.

All delay information is currently associated with directional characteristics and there are no lane configurations in the existing system.

5.3 Table Reference

This section provides a comprehensive listing of all fields in the database.

5.3.1 Accounts

FIELD NAME	TYPE	DESCRIPTION
ID	INTEGER	Unique identifier for the account.
Email	STRING	Email address of the account holder.

IsAdmin	BOOLEAN	Does the account have admin privileges?
Password	STRING	Encrypted password storage.
Salt	STRING	Value to strengthen password security.
Active	BOOLEAN	Is the account active?

5.3.2 CrossingDirections

A crossing direction represents a direction of travel.

FIELD NAME	TYPE	DESCRIPTION
ID	INTEGER	Unique identifier for the crossing direction.
CrossingID	INTEGER	Crossing associated with the crossing direction.
Identifier	STRING	Unique human-friendly identifier for the crossing direction.
FromJurisdiction	STRING	Jurisdiction of traffic origin, e.g. can.
FromRoadwayName	STRING	Roadway name in the origin jurisdiction.
ToJurisdiction	STRING	Jurisdiction of traffic destination, e.g. usa.
ToRoadwayName	STRING	Roadway name in the destination jurisdiction.
Latitude	DECIMAL	Coordinate for the port of entry related to the directional traffic flow.
Longitude	DECIMAL	Coordinate for the port of entry related to the directional traffic flow.

5.3.3 CrossingLanes

FIELD NAME	TYPE	DESCRIPTION
ID	INTEGER	Unique identifier for the crossing lane.
CrossingID	INTEGER	Crossing associated with the crossing lane.
Name	STRING	Common name for the crossing lane.
LaneIdentifier	STRING	Unique human-friendly identifier for the crossing lane.

DefaultVehicleClassID	INTEGER	Default vehicle class for the lane used when the vehicle class is not provided.
Geometry	SPATIAL	Spatial representation of the crossing lane.
IsActive	BOOLEAN	Is the crossing lane active?
CreatedBy	INTEGER	Account that created the crossing lane.
WhenCreated	DATETIME	Date and time of creation.
LastModifiedBy	INTEGER	Account that last modified the crossing lane.
WhenLastModified	DATETIME	Date and time of the last modification.

5.3.4 Crossings

FIELD NAME	TYPE	DESCRIPTION
ID	INTEGER	Unique identifier for the crossing.
Name	STRING	Common name for the crossing.
Identifier	STRING	Unique human-friendly identifier for the crossing.
Geometry	SPATIAL	Spatial representation of the crossing.
IsActive	BOOLEAN	Is the crossing active?
Region	STRING	Region to which the crossing is assigned.
CreatedBy	INTEGER	Account that created the crossing.
WhenCreated	DATETIME	Date and time of creation.
LastModifiedBy	INTEGER	Account that last modified the crossing.
WhenLastModified	DATETIME	Date and time of the last modification.

5.3.5 DateSourceConfigurations

FIELD NAME	TYPE	DESCRIPTION
Identifier	STRING	Identifier that uniquely represents the configuration within the data source.
Source	STRING	Data source associated with this

		configuration.
IsActive	BOOLEAN	Is this configuration active?
CrossingDirectionID	INTEGER	Crossing direction associated with the configuration.
CrossingLaneID	INTEGER	Crossing lane associated with the configuration.
VehicleClass	INTEGER	Vehicle class associated with the configuration.
MetricCurrentDelaySeconds	BOOLEAN	Is the current delay metric provided for the configuration.
MetricActualDelaySeconds	BOOLEAN	Is the actual delay metric provided for the configuration.
MetricPredictedDelaySeconds	BOOLEAN	Is the predicted delay metric provided for the configuration.

5.3.6 Faults

FIELD NAME	TYPE	DESCRIPTION
Id	UNIQUE IDENTIFIER	Unique identifier for the fault.
FaultType	INTEGER	Type of fault that occurred.
Target	STRING	
CreatedUtc	DATETIME	
ResolvedUtc	DATETIME	
ResolutionType	INTEGER	

5.3.7 HelpArticle

FIELD NAME	TYPE	DESCRIPTION
ID	INTEGER	Unique identifier for the help article.
Identifier	STRING	Human-readable identifier that is referenced in the application where the article is displayed.
Title	STRING	Title of the article.
Content	STRING	HTML content of the article.
CreatedBy	INTEGER	Account that created the help article.
WhenCreated	DATETIME	Date and time of creation.

LastModifiedBy	INTEGER	Account that last modified the help article.
WhenLastModified	DATETIME	Date and time of the last modification.

5.3.8 IntegratedAdapterData

FIELD NAME	TYPE	DESCRIPTION
EffectiveStart	INTEGER	Timestamp associated with this record. Effective start represents the start of a five-minute interval.
AdapterID	INTEGER	Data source adapter associated with the record.
CrossingDirectionID	INTEGER	Crossing direction associated with the record.
VehicleClass	INTEGER	Vehicle class associated with the record.
MetricID	INTEGER	Metric associated with the record.
Value	DECIMAL	Fact value of the record.
QualityPercent	INTEGER	Fact quality of the record.

5.3.9 Logs

FIELD NAME	TYPE	DESCRIPTION
Id	UNIQUE IDENTIFIER	Unique identifier for the log.
DateUtc	DATETIME	Date and time of the log creation.
LogLevel	STRING	
LogLevelValue	INTEGER	
Logger	STRING	
Message	STRING	Log message.
Exception	STRING	

5.3.10 Report

FIELD NAME	TYPE	DESCRIPTION
ID	INTEGER	Unique identifier for the report.
Name	STRING	Descriptive name for the report.

URL	STRING	URL for the web-based report.
CreatedBy	INTEGER	Account that created the report.
WhenCreated	DATETIME	Date and time of creation.
LastModifiedBy	INTEGER	Account that last modified the report.
WhenLastModified	DATETIME	Date and time of the last modification.

5.3.11 ScriptChangeLog

FIELD NAME	TYPE	DESCRIPTION
ScriptIndex	INTEGER	Index into the sequence of database updates.
Path	STRING	Path to the file containing the database updates.
AppliedUtc	DATETIME	Date and time the script was applied

5.3.12 Services

The Services table contains a list of managed services.

FIELD NAME	TYPE	DESCRIPTION
Name	STRING	Name of the managed service.

5.3.13 ServiceUptimes

FIELD NAME	TYPE	DESCRIPTION
ServiceName	STRING	Name of the managed service.
UpUtc	DATETIME	Date and time the managed service was started.
DownUtc	DATETIME	Date and time the managed service was shutdown.

5.3.14 Subscription

FIELD NAME	TYPE	DESCRIPTION
ID	INTEGER	Unique identifier for the subscription.

Email	STRING	Email address to which events related to the subscription are sent.
CrossingDirectionID	INTEGER	Crossing direction associated with the subscription.
VehicleClass	INTEGER	Vehicle class associated with the subscription.
AlertType	INTEGER	Type of subscription, i.e. daily or interval.
MinDelayMinutes	INTEGER	Threshold delay value that determines whether or not notifications should be sent.
IsActive	BOOLEAN	Is the subscription still active?
IntervalDelayCountHours	INTEGER	Number of hours to wait after *IntervalTimeHour* before sending notifications for an interval subscription.
IntervalTimeHour	INTEGER	Hour on which to start sending notifications for an interval subscription.
CreatedBy	INTEGER	Account that created the subscription.
WhenCreated	DATETIME	Date and time of creation.
LastModifiedBy	INTEGER	Account that last modified the subscription.
WhenLastModified	DATETIME	Date and time of the last modification.

5.4 Buffalo-Niagara Bluetooth Table Reference

This section provides a comprehensive listing of all fields in the database specific to data captured from the Buffalo-Niagara FreeAhead Inc. FTP site.

5.4.1 bnb_StatusFiles

FIELD NAME	TYPE	DESCRIPTION
Id	INTEGER	Unique identity of the status file.
DownloadedUtc	DATETIME	Date and time of the status file download.
DownloadMilliseconds	INTEGER	Time taken to download the file.

LastParsedUtc	DATETIME	Time the file was parsed and loaded into the database.
StatusCount	INTEGER	Number of status updates included in the file.
IsComplete	BOOLEAN	Has the status data been loaded into the database?
Filename	STRING	Filename of the status file.

5.4.2 bnb_LinkIds

This section provides a comprehensive listing of all fields in the database.

FIELD NAME	TYPE	DESCRIPTION
LinkId	STRING	Link identifier.

5.4.3 bnb_LinkDelays

This section provides a comprehensive listing of all fields in the database.

FIELD NAME	TYPE	DESCRIPTION
LinkId	STRING	Link identifier.
TimestampUtcEpochSeconds	INTEGER	Effective start timestamp for this five minute interval.
ActualDelayAverageSeconds	INTEGER	Average actual delay for the five minute interval.
ActualDelayQualityPercent	INTEGER	Data quality for the five minute interval.
ActualDelaySeconds1	INTEGER	Actual delay value for the first minute of a five minute interval.
ActualDelaySeconds2	INTEGER	Actual delay value for the first minute of a five minute interval.
ActualDelaySeconds3	INTEGER	Actual delay value for the first minute of a five minute interval.
ActualDelaySeconds4	INTEGER	Actual delay value for the first minute of a five minute interval.
ActualDelaySeconds5	INTEGER	Actual delay value for the first minute of a five minute interval.
CurrentDelayAverageSeconds	INTEGER	Average current delay for the five minute interval.

CurrentDelayQualityPercent	INTEGER	Data quality for the five minute interval.
CurrentDelaySeconds1	INTEGER	Current delay value for the first minute of a five minute interval.
CurrentDelaySeconds2	INTEGER	Current delay value for the first minute of a five minute interval.
CurrentDelaySeconds3	INTEGER	Current delay value for the first minute of a five minute interval.
CurrentDelaySeconds4	INTEGER	Current delay value for the first minute of a five minute interval.
CurrentDelaySeconds5	INTEGER	Current delay value for the first minute of a five minute interval.
PredictedDelayAverageSeconds	INTEGER	Average predicted delay for the five minute interval.
PredictedDelayQualityPercent	INTEGER	Data quality for the five minute interval.
PredictedDelaySeconds1	INTEGER	Predicted delay value for the first minute of a five minute interval.
PredictedDelaySeconds2	INTEGER	Predicted delay value for the first minute of a five minute interval.
PredictedDelaySeconds3	INTEGER	Predicted delay value for the first minute of a five minute interval.
PredictedDelaySeconds4	INTEGER	Predicted delay value for the first minute of a five minute interval.
PredictedDelaySeconds5	INTEGER	Predicted delay value for the first minute of a five minute interval.

This section provides a comprehensive listing of all fields in the database.

5.4.4 bnb_RouteIds

This section provides a comprehensive listing of all fields in the database.

FIELD NAME	TYPE	DESCRIPTION
RouteId	STRING	Route identifier.

5.4.5 bnb_RouteDelays

FIELD NAME	TYPE	DESCRIPTION

RouteId	INTEGER	Route identifier.
TimestampUtcEpochSeconds	INTEGER	Effective start timestamp for this five minute interval.
ActualDelayAverageSeconds	INTEGER	Average actual delay for the five minute interval.
ActualDelayQualityPercent	INTEGER	Data quality for the five minute interval.
ActualDelaySeconds1	INTEGER	Actual delay value for the first minute of a five minute interval.
ActualDelaySeconds2	INTEGER	Actual delay value for the second minute of a five minute interval.
ActualDelaySeconds3	INTEGER	Actual delay value for the third minute of a five minute interval.
ActualDelaySeconds4	INTEGER	Actual delay value for the fourth minute of a five minute interval.
ActualDelaySeconds5	INTEGER	Actual delay value for the fifth minute of a five minute interval.
CurrentDelayAverageSeconds	INTEGER	Average current delay for the five minute interval.
CurrentDelayQualityPercent	INTEGER	Data quality for the five minute interval.
CurrentDelaySeconds1	INTEGER	Current delay value for the first minute of a five minute interval.
CurrentDelaySeconds2	INTEGER	Current delay value for the second minute of a five minute interval.
CurrentDelaySeconds3	INTEGER	Current delay value for the third minute of a five minute interval.
CurrentDelaySeconds4	INTEGER	Current delay value for the fourth minute of a five minute interval.
CurrentDelaySeconds5	INTEGER	Current delay value for the fifth minute of a five minute interval.
PredictedDelayAverageSeconds	INTEGER	Average predicted delay for the five minute interval.
PredictedDelayQualityPercent	INTEGER	Data quality for the five minute interval.
PredictedDelaySeconds1	INTEGER	Predicted delay value for the first minute of a five minute interval.
PredictedDelaySeconds2	INTEGER	Predicted delay value for the second minute of a five minute interval.

PredictedDelaySeconds3	INTEGER	Predicted delay value for the third minute of a five minute interval.
PredictedDelaySeconds4	INTEGER	Predicted delay value for the fourth minute of a five minute interval.
PredictedDelaySeconds5	INTEGER	Predicted delay value for the fifth minute of a five minute interval.

5.4.6 bnb_LatestRouteDelays

FIELD NAME	TYPE	DESCRIPTION
RouteId	STRING	Route identifier.
TimestampUtc	DATETIME	Timestamp that corresponds to the delay.
DelaySeconds	INTEGER	Delay for the route.

5.5 Software-defined Identifiers

The tables below identify the values that are used in the database but defined in the software.

5.5.1 Vehicle Classes

VEHICLE CLASS	VALUE
Cars	0
Trucks	1
Nexus	2
Bus	3
FAST	4

5.5.1 Metrics

METRIC	VALUE
Actual Delay	0
Current Delay	1
Predicted Delay	2

5.5.2 Data Source Ids

DATA SOURCE ADAPTER	VALUE
BuffaloNiagaraBluetooth	1

CascadeGatewayAPI	2

6 Configuration

This section describes the configuration options available for the applications. Here is a list of the configuration files for each application.

APPLICATION	CONFIGURATION FILE
Web Application	Web.config
Collector Console	App.config
Glacier Backup Console	App.config
Utility Console	App.config

6.1 Notifications

In order to send notifications, including status reports and subscription notifications, the mail settings have to be configured for each application. The configuration takes the following form within the *configuration* element for each application:

```
<system.net>
    <mailSettings>
        <smtp from="donotreply@borderdatawarehouse.com">
            <network host="[host]"
                port="[port]"
                userName="[userName]"
                password="[password]"
                enableSsl="true"
                defaultCredentials="false" />
        </smtp>
    </mailSettings>
</system.net>
```

6.2 Database Connection

The web application and the collector console connect to the warehouse database. The configuration takes the following form within the *configuration* element for both of these applications.

```
<connectionStrings>
      <add name="IBI.BorderData.BuffaloNiagara"
           connectionString="[connectionString]"
           providerName="System.Data.SqlClient" />
</connectionStrings>
```

6.3 Warehouse Instances

The data sources to query and integrate are specified in the DataSources configuration for both the Web Application and the Collector Console. The adapter names for the data sources are specified in a comma-delimited format.

This option provides the ability to create instances of the warehouse for certain regions by referencing the relevant adapters.

6.4 Web Application

The following table lists the configuration options available for the Web Application.

UseLocalIntegratedData		
MaxResultSize	Limit on the number of query result rows to display in browser-based web reports.	
DataSources		

6.5 Collector Console

The following table lists the configuration options available for the Collector Console. Note that most of these options are only relevant in the collection of Buffalo-Niagara data.

collector	archiveStatusFileDirectory newStatusFileDirectory useFtpProvider keepPeriod	
ftpStatusFileProvider	hostname port	

	username password directory	
webStatusProvider	baseUrl	
DataSources		
mail.to		
StatusFileDiscoveryWorker%	Control that adjusts resources dedicated to the Buffalo-Niagara status file discovery task. 0 = off, 100 = max	
StatusFileParseWorker%	Control that adjusts resources dedicated to the Buffalo-Niagara status file parse task. 0 = off, 100 = max	
StatusFileDownloadWorker%	Control that adjusts resources dedicated to the Buffalo-Niagara status file download task. 0 = off, 100 = max	

6.6 Glacier Backup Console

The following table lists the configuration options available for the Glacier Backup Console.

AWSAccessKey
AWSSecretKey
AWSRegion
VaultName
BackupDirectory
ArchiveDescription
NotificationEmailAddresses

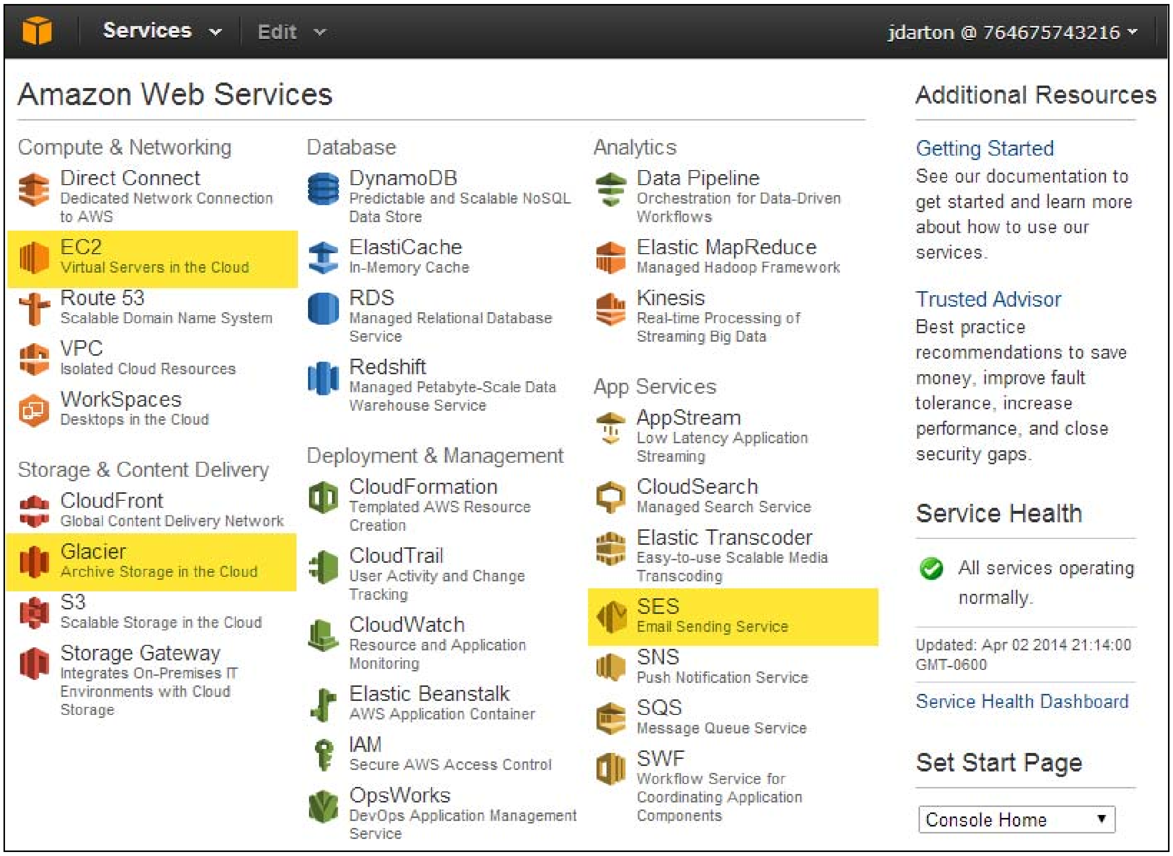
6.7 Utility Console

DataSources	Data sources to be referenced by the console application.

7 Amazon Web Services Console

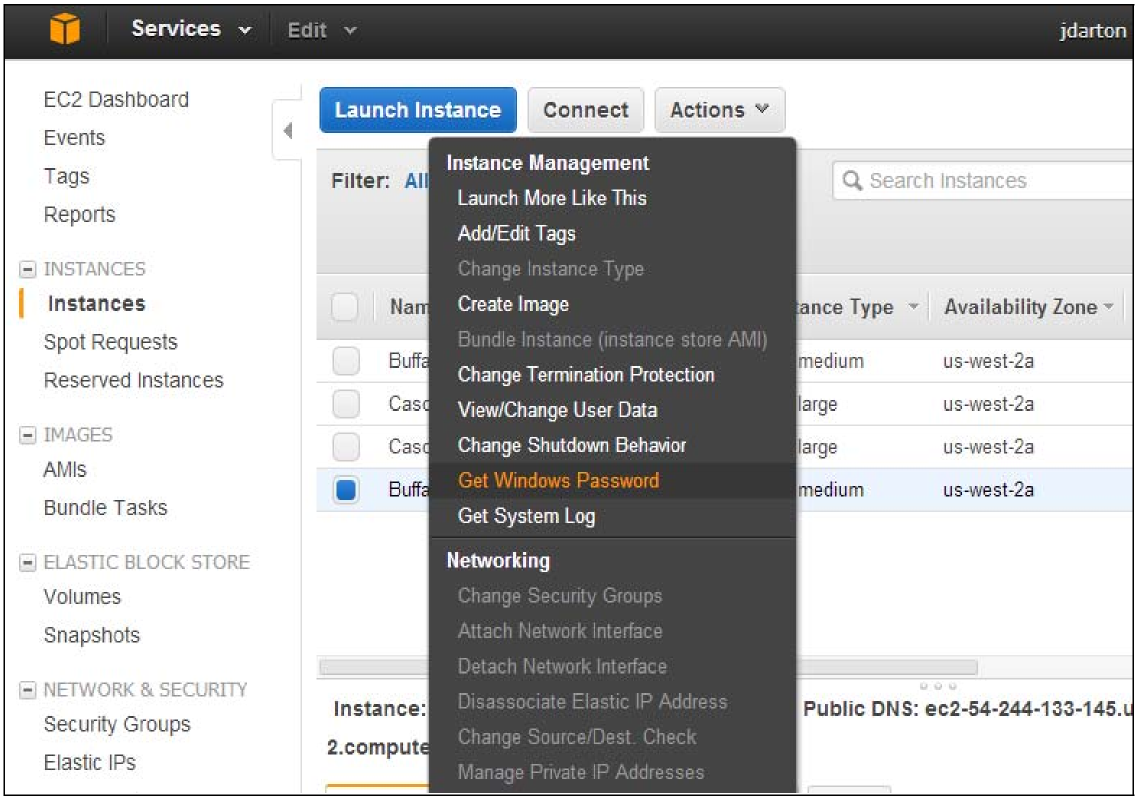
The Amazon Web Services console secure login can be accessed using the following link: https://764675743216.signin.aws.amazon.com/console

The screenshot below shows the Amazon Web Services console. The relevant services for the NBDW system that are described throughout this document are highlighted in yellow.



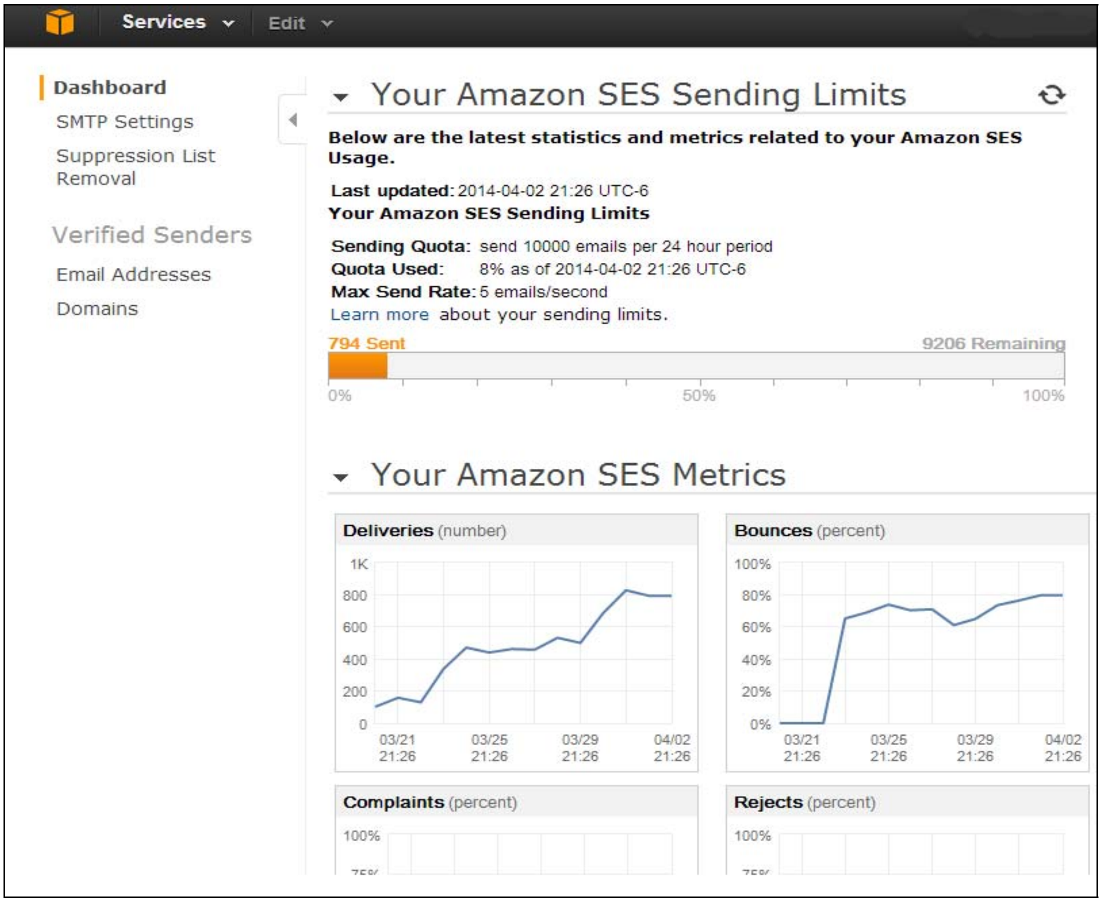
7.1 EC2 Management Interface

The EC2 Management Interface provides complete access and control of the NBDW Web and Database server instances. The EC2 firewall and access permissions can be configured from this interface including the ability to manually reset the server instance in the event of an issue.



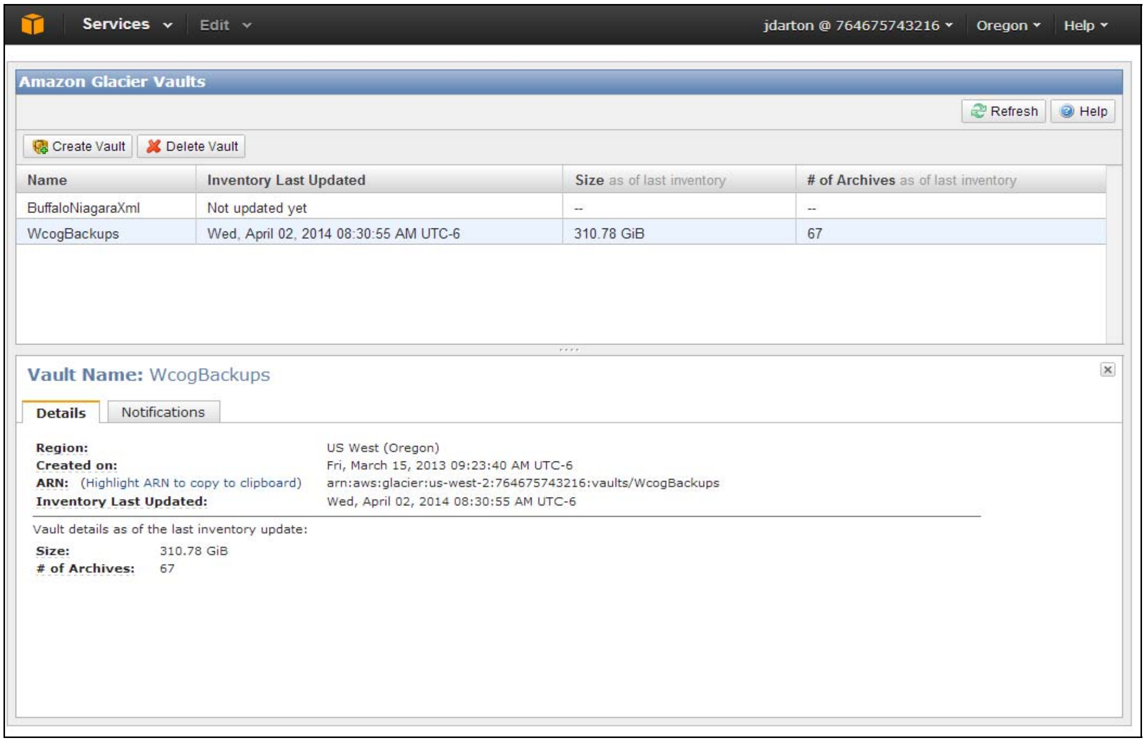
7.2 SES Management Interface

The SES Management Interface is used to configure settings for email relays. This interface can also be used to block/unblock problematic email addresses and to view statistics such as deliveries and email bounces.



7.3 Glacier Management Interface

The Glacier Management Interface allows for the creation control of vaults used for offsite data backup.



Appendix F: Cost estimate for additional crossings

Based on discussions with the website and archive developer, IBI Group, the following cost estimates were developed for connecting a new border wait time system to the national BDW. Note that these costs are for the common data elements being stored on the national archive, delay by vehicle type, not region-specific data such as loop detector volumes.

A system that has an API for data sharing

If the system to be added to the BDW has an application programming interface (API) in place then the following steps are required to add the new system's data into the warehouse:

Steps to add a new BWT system	Budget
Review site context, route, vehicle types	$1,600
Review API	$3,200
Obtain and analyze sample data from API	$2,000
Configure data collection engine for using API	$7,000
Collect data (monitor and validate)	$1,600
Stakeholder review and updates (test environment)	$3,200
Release to production/backfill collected data	$3,200
Project management and meetings (15% of above)	$2,180
Estimated total:	**$23,980**

Note that a system identical to the Buffalo-Niagara border wait time system, using the same technology and output, would have a cost quite less than the $23,980 estimated above, as the existing data collection methodology and output would be the same.

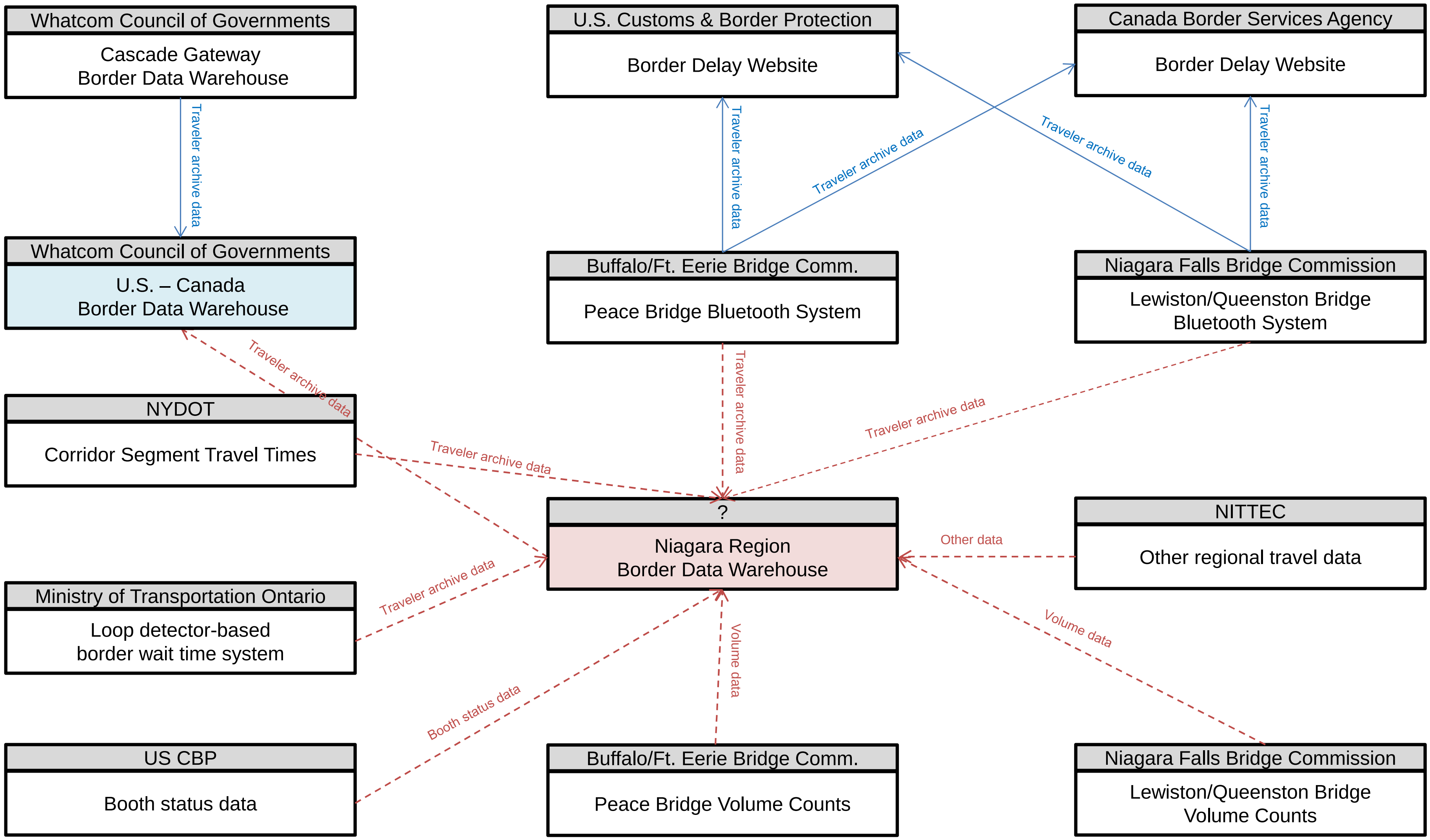
A system that has no API for data sharing

If the border wait time system outputs being integrated into the BDW come from a system that does not have an API in place then there will be additional costs in developing an interface to collect the data from the system.

Steps to add a new BWT system	Budget
Review site context, route, vehicle types	$3,200
Obtain and analyze sample data from API	$3,200
Develop interface	$14,000
Configure data collection engine for using new interface	$7,000
Collect data (monitor and validate)	$3,200
Stakeholder review and updates (test environment)	$3,200
Release to production/backfill collected data	$3,200
Project management and meetings (15% of above)	$3,700
Estimated total:	**$40,700**

Appendix G: Niagara border wait time project schematic

U.S. – CANADA BORDER DATA WAREHOUSE ARCHITECTURE
WITH A FUTURE NIAGARA REGIONAL SYSTEM



Appendix H: Border Data Warehouse XML schema

At the outset of this project WCOG worked with the developer IBI Group to identify issues with the existing XML schema used in the Cascade Gateway Border Data Warehouse with the intention of resolving some of those critical issues in a new standardized XML schema that would rectify those issues as well as serve as a standard for future border data warehouse installments.

The first effort of the project involved developing a table illustrating the inventory and structure of an ideal XML schema that would reflect the reality at the border crossings, provide data in the multitude of formats needed to incorporate varying data types, and that would clarify important formatting factors to ease the merging of data sets from multiple sources.

Original needs proposal

The following document describes the new proposed schema for the Cascade Gateway Data Warehouse (WCOG). The schema is used for the purpose of transmitting data for crossing and detector data. The proposed schema enhances the ability to provide data for crossings, booths and detectors and introduces the concept of an inventory that creates relationships between a Crossing, Booth and Detector.

Crossing – A crossing is defined as a physical border crossing in a specific direction. An example of a crossing is 'Peace Arch Southbound'

Booth – A booth is a location at a crossing at a specific lane.

Detector – A detector is a device that collects various traffic data (volume, speed, occupancy, etc)

Proposed XML Schema

The following shows the proposed schema as well as the explanation of each element of the xml schema and its elements. The inventory sections describes the parts of the schema that deal with the inventory that defines the relationships between the crossings, booths and detectors. The data portion of the schema is used to provide actual data delivered for crossings, booths and detectors.

Inventory Elements

Element	Type	Description	Attributes
BorderCrossingData		Top level node	
Organization-id		Unique identifier for the data feed. Currently BCMot, WSDot	
Inventory		Top node for the inventory of detectors, booths and crossings	
Detectors		Collection of detector nodes	
Detector		Node that defines a specific detector	
Detector.Id	String (mandatory)	Unique identifier for the detector	
Detector.Name	String (mandatory)	Display name for the detector	
Detector.Device-ID	String (mandatory)	Id for the device that collects for the detector	

Detector.Device-Type	Enumeration (mandatory)	Type of detector device, ie VDS, BlueTooth, etc. An enumeration of device types should be defined	
Detector.Lanes		Collection of lanes that are covered by the detector	
Detector.Lanes.LaneNumber	Numeric (mandatory)	Lane number (1, 2,3, etc)	
Detector.Road-Name	String (optional)	Name for the road for the detector	
Detector.Direction	Enumeration (optional)	Direction for the detector An enumeration of directions should be defined, is North, South, West, East ok?	
Detector-Booth-Id	Numeric (optional)	If the detector is mapped to a specific booth, the ID of the booth	
Booths		Collection of booth nodes	
Booth		Node that defines a booth at a crossing	
Booth.Id	String (mandatory)	Unique id for the booth	
Booth.Type	Enumeration (mandatory)	Type of booth Enumeration of types needs to be defined. Cars, Nexus, Bus, etc	
Booth.Direction	Enumeration (optional)	Direction for the booth An enumeration of directions should be defined, is North, South, West, East ok?	
Booth.Lane-Number	Numeric (mandatory)	Lane number (1, 2,3, etc)	
Booth-Road-Name	String (optional)	Name for the road for the booth	
Crossings		Collection of crossings	
Crossing		Node that defines a crossing	
Crossing.Id	String (mandatory)	Unique id for the crossing	
Crossing.Name	String (mandatory)	Name of the crossing	
Crossing.Direction	Enumeration (optional)	Direction for the crossing An enumeration of directions should be defined, is North, South, West, East ok?	
Crossing.Road-Name	String (optional)	Name for the road for the crossing	
Crossing.Booths		Collection of booths that make up a crossing	
Crossing.Booth.Id		ID for the booth	

Data Elements

Element	Type	Description	Attributes
Data		Start of the data for the report	
Collection-Period	Mandatory	Node that defines the collection timeframe for the data. Multiple collection reports can be defined within a single xml feed	
Collection-period-item	Mandatory	Node that defines the start/end of the collection period	
Collection-period-item.Date	String (mandatory)	Date in format yyyymmdd	
Collection-period-item.Start Hour	Numeric (mandatory)	Start Hour for the collection period 00-23	
Collection-period-	Numeric	Start Minute in 5 minute increments: 0, 5,	

item.Start Minute	(mandatory)	10, 15, 20, 25, 30, 35, 40, 45, 50, 55	
Collection-period-item.End Hour	Numeric (mandatory)	End Hour for the collection period 00-23	
Collection-period-item.End Minute	Numeric (mandatory)	End Minute in 5 minute increments: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55	
Collection-period-item measurement-duration-sec	Numeric (mandatory)	Number of seconds for the collection period (300 – for 5 minute aggregations)	
Crossing-data	Mandatory	Node that contains a collection of crossing reports	
Crossing-report	Mandatory	Node that contains crossing data	
Crossing-report.ID	String (mandatory)	Id for the crossing (references the inventory)	
Crossing-report.Status	String (optional)	Open or closed, by default open	
Crossing-report.Delay-Min	Numeric (optional)	Delay for the crossing in minutes	Status – Error – if the data contains errors or is invalid. This attribute is optional
Crossing-report.Service Rate	Numeric (optional)	Service rate for the crossing	Status – Error – if the data contains errors or is invalid. This attribute is optional
Crossing-report.Volume	Numeric (optional)	Volume for the crossing	Status – Error – if the data contains errors or is invalid. This attribute is optional
Booth-data	Mandatory	Node that contains a collection of booth reports	
Booth-report	Mandatory	Node that contains booth data	
Booth-report.Id	String (mandatory)	Unique ID for a booth report	
Booth-report.Nationality US	Numeric (optional)	???????	
Booth-report.Nationallity. Can	Numeric (optional)	???????	
Booth-report. Departure Rate	Numeric (optional)		
Detector-Data	Mandatory	Node that contains a collection of detector reports	
Detector-Report	Mandatory	Node that contains a detector report	
Detector-Report.Id	String (mandatory)		
Detector-Report.Status	String (optional)		
Detector-Report.Lanes	Mandatory	Collection of lanes for the detector	
Lane	Numeric (mandatory)	A lane for a detector	Number for the lane
Lane.Volume	Numeric (optional)	Volume for the detector	Status – Error – if the data contains errors or is invalid. This attribute is optional
Lane.Occupancy	Numeric (optional)	Occupancy for the detector	Status – Error – if the data contains errors or is invalid. This attribute is

			optional
Lane.Vehicle Speed km	Numeric (optional)	Speed for the vehicles in km/hr	Status – Error – if the data contains errors or is invalid. This attribute is optional
Lane.Vehicle Length Meters	Numeric (optional)	Length of vehicle in meters	Status – Error – if the data contains errors or is invalid. This attribute is optional

Sample Schema

```
<?xml version="1.0" encoding="UTF-8"?>
<borderCrossingData xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="borderCrossing.xsd">
<organization-id>BCMoT</organization-id>
        <inventory>
                <detectors>
                        <detector>
                                <id></id >
                                <name></name>
                                <device-id></device-id>
                                <device-type> </device-type>
                                <lanes>
                                        <lane-number></lane-number>
                                        <lane-number></lane-number>
                                        <lane-number></lane-number>
                                </lanes>
                                <road-name></road-name>
                                <direction></direction>
                                <booth-id>4</booth-id>
                        </detector>
                </detectors>
                <booths>
                        <booth>
                                <id></id>
                                <type></type>
                                <direction></direction>
                                <lane-number></lane-number>
                                <road-name></road-name>
                        </booth>
                </booths>
```

```
        <crossings>
            <crossing>
                <id></id>
                <name></name>
                <direction></direction>
                <road-name></road-name>
                <booths>
                    <id></id>
                    <id></id>
                    <id></id>
                </booths>
            </crossing>
        </crossings>
    </inventory>
    <data>
    <collection-period>
        <collection-period-item>
            <date></date>
            <start-hour></start-hour>
            <start-minute></start-minute>
            <end-hour><end-hour>
            <end-minute></end-minute>
            <measurement-duration-sec></measurement-duration-sec>
        <crossing-data>
            <crossing-report>
                <crossing-id></crossing-direction-id>
                <status></status>
                <delay-min status=”error’></delay-min>
                <service-rate status=”error’></service-rate>
                <volume status=”error’></ volume >
            </ crossing-report >
        </crossing-data>
        <booth-data>
            <booth-report>
                <id><id>
                <nationality-us></nationality-us>
                <nationality-can></nationality-can>
                <departure rate-sec></departure rate>
            </ booth-report >
        </ booth -data>
        <detector-data>
```

```
            <detector-report>
                <id></id>
                <status> </status>
                <lanes>
                    <lane number=1>
                        <volume status=”error’></lane-vehicle-volume>
                        <occupancy status=”error’>0</occupancy>
                        <vehicle-speed-km status=”error’>0</vehicle-
speed>
                        <vehicle-length-meters status=”error’>0</vehicle-
length>
                    <lane>
                </lanes>
            <detector-report>
        </ detector -data>
```


Revised strategy

However upon completion of this specific template it was then decided to revert back to the TMDD structure for the most universal ease of use for other developers.

The following .xml files were created based on the Traffic Management Data Dictionary (TMDD) standards structure and also includes a number of custom tags (bwt) for elements needed for the wait time system that don’t exist in the TMDD.

More information about the TMDD is available online at: http://www.ite.org/standards/tmdd/

WCOG_Status.xml


```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<status xmlns:tmdd="http://www.tmdd.org/3/messages"
xmlns:bwt="http://www.borderwaittime.com/schema">

  <!-- Crossing statuses -->
  <bwt:crossingStatusMsg>
    <crossing-status-item>
      <organization-information>
        <organization-id>BCMoT</organization-id>
      </organization-information>
      <crossing-id>Lynden/Aldergrove</crossing-id>
      <crossing-status>open</crossing-status>
    </crossing-status-item>
  </bwt:crossingStatusMsg>
```

```
<!-- Link statuses -->
<tmdd:linkStatusMsg>
  <link-status-item>
    <organization-information>
      <organization-id>BCMoT</organization-id>
    </organization-information>
    <link-list>
      <link>
        <network-id>BorderCrossingData</network-id>
        <link-id>EB 8th from Route 99 to Route 15</link-id>
        <link-status>open</link-status>
        <last-update-time>
          <date>20130714</date>
          <time>000500</time>
          <offset>+0000</offset>
        </last-update-time>
        <bwt:LinkStatusExt>
          <restriction-vehicle-type>
            <vehicle-types>CarNexus</vehicle-types>
            <vehicle-types>CarNonNexus</vehicle-types>
          </restriction-vehicle-type>
          <crossing-delay>
            <current>62</current>
            <actual>62</actual>
            <predicted>0</predicted>
          </crossing-delay>
          <service-rate>10</service-rate>
        </bwt:LinkStatusExt>
      </link>
    </link-list>
  </link-status-item>
</tmdd:linkStatusMsg>

<!-- Detector statuses -->
<tmdd:detectorStatusMsg>
  <detector-status-item>
    <detector-list>
      <detector>
        <detector-status-header>
          <organization-information>
            <organization-id>BCMoT</organization-id>
          </organization-information>
          <device-id>9901-1 upstream</device-id>
          <device-status>on</device-status>
        </detector-status-header>
      </detector>
      <detector>
```

```
        <detector-status-header>
          <organization-information>
            <organization-id>BCMoT</organization-id>
          </organization-information>
          <device-id>9904-1 downstream</device-id>
          <device-status>unavailable</device-status>
        </detector-status-header>
      </detector>
    </detector-list>
  </detector-status-item>
</tmdd:detectorStatusMsg>

<!-- Detector data -->
<tmdd:detectorDataMsg>
  <detector-data-item>
    <organization-information>
      <organization-id>BCMoT</organization-id>
    </organization-information>
    <detector-list>
      <detector-data-detail>
        <station-id>9901</station-id>
        <detector-id>9901-1 upstream</detector-id>
        <detection-time-stamp>
          <date>20130714</date>
          <time>000500</time>
          <offset>+0000</offset>
        </detection-time-stamp>
        <vehicle-count>5</vehicle-count>
        <vehicle-occupancy>55</vehicle-occupancy>
        <start-time>
          <date>20130714</date>
          <time>000000</time>
          <offset>+0000</offset>
        </start-time>
        <end-time>
          <date>20130714</date>
          <time>000500</time>
          <offset>+0000</offset>
        </end-time>
        <detector-data-type>actual</detector-data-type>
        <vehicle-speed>6</vehicle-speed>
        <bwt:DetectorDataExt>
          <avg-vehicle-length>34</avg-vehicle-length>
        </bwt:DetectorDataExt>
      </detector-data-detail>
    </detector-list>
  </detector-data-item>
```

```
  </tmdd:detectorDataMsg>
</status>
```


WCOG_Inventory.xml


```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<inventory xmlns:tmdd="http://www.tmdd.org/3/messages"
xmlns:bwt="http://www.borderwaittime.com/schema">

  <!-- Crossing inventory -->
  <bwt:crossingInventoryMsg>
    <crossing-inventory-item>
      <organization-information>
        <organization-id>BCMoT</organization-id>
      </organization-information>
      <crossing-list>
        <crossing>
          <crossing-id>Lynden/Aldergrove</crossing-id>
          <crossing-location>
            <latitude>0</latitude>
            <longitude>0</longitude>
          </crossing-location>
        </crossing>
      </crossing-list>
    </crossing-inventory-item>
  </bwt:crossingInventoryMsg>

  <!-- Link inventory -->
  <tmdd:linkInventoryMsg>
    <link-inventory-item>
      <organization-information>
        <organization-id>BCMoT</organization-id>
      </organization-information>
      <link-list>
        <link>
          <network-id>BorderCrossingData</network-id>
          <link-id>EB 8th from Route 99 to Route 15</link-id>
          <link-type>other</link-type>
          <link-begin-node-id>0</link-begin-node-id>
          <link-begin-node-location>
            <latitude>0</latitude>
            <longitude>0</longitude>
```

```
    </link-begin-node-location>
    <link-end-node-id>0</link-end-node-id>
    <link-end-node-location>
     <latitude>0</latitude>
     <longitude>0</longitude>
    </link-end-node-location>
    <bwt:LinkInventoryExt>
     <crossing-id>Lynden/Aldergrove</crossing-id>
     <crossing-direction>canada-bound</crossing-direction>
     <crossing-lane-numbers>
      <lanes>1</lanes>
      <lanes>2</lanes>
     </crossing-lane-numbers>
    </bwt:LinkInventoryExt>
   </link>
  </link-list>
 </link-inventory-item>
</tmdd:linkInventoryMsg>

<!-- Detector inventory -->
<tmdd:detectorInventoryMsg>
 <detector-inventory-item>
  <detector-station-inventory-header>
   <organization-information>
    <organization-id>BCMoT</organization-id>
   </organization-information>
   <device-id>9901</device-id>
   <device-location>
    <latitude>0</latitude>
    <longitude>0</longitude>
   </device-location>
   <device-name>Test</device-name>
  </detector-station-inventory-header>
  <detector-list>
   <detector>
    <detector-inventory-header>
     <organization-information>
      <organization-id>BCMoT</organization-id>
     </organization-information>
     <device-id>9901-1 upstream</device-id>
     <device-location>
```

```
          <latitude>0</latitude>
          <longitude>0</longitude>
        </device-location>
        <device-name>9901-1 upstream</device-name>
      </detector-inventory-header>
      <detector-type>inductive loop</detector-type>
      <detection-lanes>
        <lanes>1</lanes>
      </detection-lanes>
      <bwt:DetectorInventoryExt>
        <crossing-id>Lynden/Aldergrove</crossing-id>
        <crossing-direction>canada-bound</crossing-direction>
        <crossing-lane-numbers>
          <lanes>1</lanes>
          <lanes>2</lanes>
        </crossing-lane-numbers>
        <crossing-volume-index>4</crossing-volume-index>
      </bwt:DetectorInventoryExt>
    </detector>
   </detector-list>
  </detector-inventory-item>
 </tmdd:detectorInventoryMsg>
</inventory>
```