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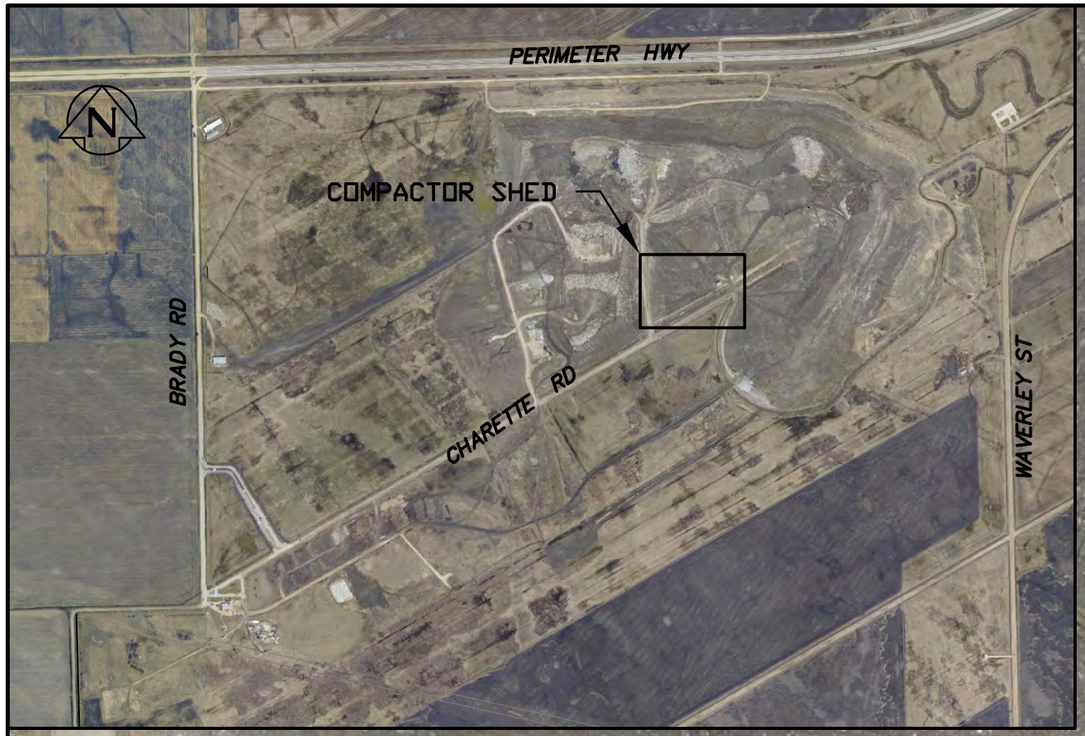
THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT

BRADY ROAD LANDFILL

EQUIPMENT AND STORAGE BUILDINGS

SHEET 1 OF 1

FIGURE 4-8A



THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT
SOLID WASTE DIVISION

BRADY ROAD LANDFILL	SHEET 1 OF 1
EQUIPMENT AND STORAGE BUILDINGS	FIGURE 4-8B

The Facility is serviced by two inbound scales and one outbound scale. These pit-less type scales are 27 m long by 3 m wide and have a 60 tonne gross vehicle weight rating. The scales are interfaced with the on-site computer system to produce weigh tickets and statistical data.

The scale is annually certified by the federal department of Weights and Measures. Mud and snow is not allowed to accumulate in and around the scale, so as to prevent constraints on the accuracy of weighing. Regular maintenance, including steaming of the scale is carried out as needed in accordance with the manufacturer's recommendations.

All inbound lanes will be equipped with radiation detectors. Weighmasters will follow manufacturer's protocol to verify any alarms. In the event of an alarm the Weighmaster will contact the Foreman.

4.5.4 Fencing, Gates and Security

Site-security measures are designed to prevent unauthorized persons from entering the site, to protect the facility and its equipment from possible damage caused by trespassers, and to prevent disruption of facility operations caused by unauthorized site entry. Access to the facility is restricted by fences. The site entrances are secured by gates and are monitored by authorized personal during site-operating hours. Outside operating hours, the gates to the site are locked.

Entry to the active portion of the site is restricted to designated personnel, approved waste haulers, and properly identified persons whose entry is authorized by assigned Landfill staff. Visitors are allowed at the active area only when accompanied by the assigned Landfill staff or his/her representative.

The site is secured with a perimeter fence and lockable gates. The facility is locked during non-operational hours. The scalehouse is equipped with a security system.

4.5.5 Signage

A prominent sign is displayed at the entrance to the site. This sign will state the new name of the site ("The Brady Road Resources Management Facility"), hours and days of operation. The site sign will include a 24-hour emergency contact. Along with the standard identification sign, guidelines for waste acceptance and rules of conduct will be posted at the facility entrance.

Additional signage will include waste acceptance restrictions, material separation requirements and directional signs.

In general, signs will provide site users with necessary information to safely dispose of acceptable materials in an orderly and efficient manner. Proper signage will minimize operational problems and reduce time requirements of staff in directing and informing the public and collecting and disposing of wastes unloaded at incorrect locations.

4.5.6 Buffer Area and Landscaping

The current and future separation of the fill limits from property lines is illustrated in Figures 1-1 and 1-2.

The primary purpose of the buffer area is to provide a buffer against encroachment of private property. Construction of berms and tree planting is or will be carried out to screen operations from adjacent developing lands.

Landscaping is primarily undertaken along the buffer area between the landfill limit and the property boundary, especially along the north and east sides. The site will be the recipient of a significant landscaping effort, as portions of the site are completed, to allow on-site public recreation and encourage visual screening from adjoining lands. Vegetation of soil cover will occur in a portion of the current landfill being retrofitted for landfill-gas recovery. Starting initially near the property margins with appropriate cultivars of fast-growing full-canopy trees (e.g., hybrid poplar), visual screening of the site will commence on the north and east sides, facing the growing subdivision development on these sides of the landfill. Slower-growing trees (e.g., willow and evergreens) will infill behind the poplars, to add to the visual screening and sound deadening, and to create year-round botanical screening and improved site aesthetics.

Landscaped areas will be maintained by the City staff, to keep the grassed area clean of litter and mown on a regular basis. Vehicular traffic shall be precluded from these areas, except for mowing and watering. Areas will be vegetated to help mitigate windblown dust.

4.6 COMPLIANCE WITH REGULATION AND 'BEST PRACTICES'

4.6.1 Compliance with *Waste Disposal Grounds Regulation*

Pursuant to section 3(1) of the *Waste Disposal Grounds Regulation*, a licence in accordance with section 11 of the Act must be received prior to new construction, operation or expansion of a Class 1 WDG. Further, section 3(2) of the Regulation requires that Class 1 WDGs are operated in accordance with an operating permit.

In this regard, operations of the facility do not comply with section 3(1) of the *Waste Disposal Grounds Regulation*, because while operations are permitted pursuant to section 3(2) of MR 150/91, they are not licensed, as required by the Act.

If the City is granted the requested *Environment Act* licence, then the facility will be fully compliant with these key provincial requirements.

4.6.2 Compliance with 'Best Practices'

Stantec conducted a Best Practices (BP) Review of the Brady Road Landfill facility in relation to the operational standard of performance of two selected award-winning western Canadian

landfills. Best Practices relevant to the local climate and topography were distilled into a checklist from published BP guidelines from North America and Australia (Stantec, 2011c).

The review identified that the Brady Road facility is relatively well operated and satisfies (i.e., achieved rankings of “is not non-compliant” or “complies”) the majority (66%) of the criteria in the checklist. The exercise resulted in 41 suggested actions or improvements in 21 categories (Stantec, 2011c, Appendix A, Table 2), many of which have since been responded to by the City.

The prompt response by the City to the “Action List” produced by the Phase 1 ELP has reduced the number of risk sources and vectors having potential for environmental impact. This has contributed to the focusing of assessment effort outlined in Section 7.3.

4.7 DAILY OPERATIONS

4.7.1 Hours of Operation

Full-time site supervision by the operations staff is provided during hours that the Facility is open (Table 4-3). During non-operating hours, the Facility is closed and the site office and entrance gate are closed and locked.

Table 4-3: Hours of Operation, Brady Road Resource Management Facility

Season	Opens	Closes
Summer (May to October)	5:30 a.m.	8 p.m.
Winter (November to April)	5:30 a.m.	6 p.m.

The Facility is closed November 11 (Remembrance Day), December 25 (Christmas Day) and January 1 (New Year’s Day).

During shorter daylight hours in the winter, a portable lighting tower system is used to illuminate the tipping area to ensure good visibility and safe operations.

After hours, illegal dumping of wastes can periodically occur at the entrance gate or elsewhere in the vicinity of the landfill. If observed, landfill staff seek to identify the responsible party. Any evidence obtained is used for prosecution purposes.

4.7.2 Scavenging

Scavenging is not allowed at the facility, to prevent serious injury (or possible fatality) that could occur while scavenging at the site, or when using or consuming scavenged materials. Such activities also interfere with operations.

Scavenging is prohibited by the Solid Waste Bylaw at waste processing or disposal facilities operated by the City. The Landfill Supervisor may, however, authorize the sampling of materials from wastes received at the facility for purposes of study, research, testing for inherent value and repurposing or processing, etc.

4.7.3 Burning

Fires are a hazard to the business and lives of workers and clients; therefore, no open burning whatsoever is allowed at the facility.

4.7.4 Waste Acceptance

4.7.4.1 Waste Documentation

Waste is placed according to a fill plan approved by the Landfill Supervisor.

The City utilizes a sophisticated computer program for managing the site and billings. The system also records and compiles waste statistics, and tracks materials by type and source.

Recorded data include hauler identification, date received, weigh ticket number, quantity received, type of material and general source. The location of asbestos and SRM burial is tracked with GPS and maintained in written records.

4.7.4.2 Prohibited Waste Sources

Monitoring of waste directed to the landfill is critical and is carried out in ways intended to protect the environment. Waste disposal at the landfill is monitored and routinely inspected.

Every attempt is made by the City and facility staff to prevent unacceptable waste from being disposed of at the landfill. The City makes itself aware of industries in the immediate area that could produce and inappropriately send unacceptable waste to the facility. Staff are provided ongoing training to identify and handle waste in accordance with procedures for unacceptable materials.

Nevertheless, wastes containing hazardous or restricted materials can sometimes be delivered to the site. Although hazardous materials are not accepted at the facility, staff have a response and secondary inspection plan in effect if such materials reach the tipping face.

The facility staff, including weighmasters, traffic directors and equipment operators, are alert for, do not accept, and notify the Landfill Supervisor, when:

- The waste hauler does not have proper documentation.

- Waste is in barrels or other sealed containers. Containers or barrels are opened by the hauler and the contents verified by City staff as “acceptable” prior to its acceptance for disposal.
- Waste is a sludge or semi-solid form.
- Waste is a powder or gaseous.
- Waste has extreme odours.
- Waste is hauled by vacuum/tank truck, which is not allowed to enter the site.
- Waste has an unusual appearance.
- Waste is in a container, drum, bucket, can, crate or box with warning labels.
- Facility-operating personnel are not familiar with the waste.
- The waste load is leaking fluids of any kind.
- Waste origin is from an oil and gas company or a service station.

4.7.4.3 Prohibited Waste Types

The following are not acceptable for disposal at the cell working face:

- Hazardous waste.
- Biomedical waste.
- Liquid waste.
- Hydrocarbon-contaminated soils (unless approved by the City’s special waste technician).
- Waste oil, including contaminated soils (unless approved by the City’s special waste technician).
- Paints, solvents, etc.
- Vehicle bodies.

The Brady Road landfill excludes prohibited wastes including, but not limited to, liquid wastes, regulated hazardous and PCB wastes, ammunition, explosives, guns, mercury switches, biomedical waste, and radioactive waste. A sign at the entrance identifies common prohibited

wastes to the public. Gate attendants (i.e., weighmasters) provide an initial screening for prohibited wastes is followed by observations at the working face by landfill personnel.

4.7.4.4 Enforcing Waste Prohibitions

Should any waste material be unloaded and found to be suspect, the following procedure is followed:

- Staff immediately direct the vehicle operator to stop unloading the remainder of load.
- Staff attempt to identify the waste and isolate it from other waste.
- If a hazardous waste could spread, the waste is contained and the area where the unacceptable or hazardous waste was disposed is immediately isolated and secured (e.g., an earth berm is constructed, or the material is removed to a less sensitive area using landfill equipment).
- Staff obtain information from the hauler with respect to name, company name, license plate number and origin of the waste (address) and a description of the driver and the hauling vehicle.
- The Landfill Supervisor is notified when such waste is found. The Landfill Supervisor arranges for a sample of the waste to be taken and analyzed.
- Staff notify regulatory agencies upon instruction of the Landfill Supervisor.

4.7.4.5 Special Waste Handling

Asbestos-Containing Material (ACM)

The facility accepts some asbestos-containing wastes. These special wastes are handled in a manner consistent with applicable regulations or City policies, and within prescriptions applicable to the site. Any waste requiring special disposal and or handling that is not identified is assessed by the City's special waste technician for acceptability and disposal requirements.

ACM is accepted provided the waste is bagged, buried immediately according to the asbestos procedure, and the location is logged using GPS coordinates.

Dead Animals including Specified Risk Material (SRM)

The site receives dead animals including SRM or slaughterhouse wastes that are delivered to the site independent of other wastes. Dead animals or slaughterhouse waste is buried and covered immediately following receipt with cover that is adequate to deter vector (animal) scavenging. The SRM disposal area locations are logged with GPS coordinates. SRM is

accepted only with the proper documentation. Such burials are made consistent with prescriptions provided by Canadian Food Inspection Agency (CFIA).

4.7.4.6 Segregated Storage Area

Waste materials that can be recycled are diverted to the recycling area. The Scale Operator and other facility staff direct vehicles to the appropriate discharge area. For example:

- Waste metals – diverted to the waste metals area.
- White goods – diverted to the white goods area.
- Used tires – diverted to the used tire storage area.
- Green Waste – diverted to the green waste area.
- Glass – diverted to the processing area.

Contracts are maintained by the City of Winnipeg with recycling contractors to haul recyclable materials from the facility.

Waste Metals / White Goods

This category includes: scrap metal, white goods (stoves, refrigerators, etc.) and batteries.

Waste metal is segregated and periodically hauled to a scrap-metal dealer. Appliances containing Freon are stored in a designated area where a certified contractor removes the Freon storage vessel for off-site removal of Freon.

Used Tires

Used tires are accepted at the landfill. Tires are segregated in a designated recycling area.

Bicycles

Bicycles capable of being refurbished are directed to a designated area for refurbishment.

Propane Tanks

The City does encourage empty propane tanks segregation for recycling. These are stored for later pick-up by a recycling contractor. Propane tanks are not left at the landfill working face. A designated contractor regularly collects propane tanks.

Green Waste

Trees, brush, and wood waste are collected. Wood materials not used by Wood Anchor can be chipped and can be added to compost.

Street Sweepings / Sand Recycling Area

Street sweepings are directed to an area for stockpiling pending a decision on a new sand recycling program at the landfill.

Composting Area

Yard and garden waste (e.g., leaves, grass, plant debris, small brush) is processed in a designated composting area. This area is located on natural ground capped with an impervious compacted clay cap or equivalent.

Material delivered to the site is trommel screened and/or chipped to remove unacceptable/non-organic material and then placed in windrows for composting. The windrows are turned periodically to maintain optimum temperature, oxygen levels and moisture content.

After composting, the windrowed material is moved to a curing pile to stabilize the compost or placed as a soil amendment, if suitable.

Hazardous Waste

No household, commercial or industrial hazardous waste, radioactive waste, explosives or ammunition is accepted at the site.

Waste Oil

Waste oil is not accepted at the site from the general public. Waste oil generated from site operations equipment is collected for recycling.

Batteries

Batteries delivered to the recycling area are stored there for recycling.

4.7.5 Waste Placement and Compaction

4.7.5.1 General

City staff seek to meet the objectives of active area filling operations, which include:

- Maximizing airspace available for waste placement.

- Controlling the size of the working face, placing intermediate cover as cell filling advances, and covering the working face as necessary to control nuisances.
- Maintaining grades so as to control surface run-on/run-off.
- Placement of interim cover when areas are to be left for lengthy periods (three months in summer and six months in winter), before continuing waste placement operations. The interim cover is to restrict moisture entry into the fill and to limit blowing of wastes.
- Placement of final cover and vegetating after completed areas reach final grades.

4.7.5.2 Vehicle Control

Access to the working face is via the site-access roads. The access-road system is maintained throughout filling operations. Maintenance procedures for the road include grading, gravel surfacing and cleaning of spilled material, or snow removal following snowfalls, on an as-needed basis. The road is graded so that it slopes slightly inwards towards the cell, so that potentially contaminated runoff is contained in the cell and other on-site drainage facilities.

Incoming vehicles are weighed on the scale and proceed along the active access road, as per directional signs, to the working face. The waste hauler then moves to the disposal area for off-loading, as directed by the Traffic Director, then returns along the same access road to the scale or site exit.

The majority of haulers do not require weighing out at the scale after waste has been unloaded in the cell, because their tare weights are recorded.

4.7.5.3 Working Face Practices

The following main factors are addressed in carrying out ongoing cell-filling operations:

- Maintaining prescribed lift thickness.
- Maximizing compaction.
- Applying daily cover.
- Maintaining diligence for fire prevention.
- Optimizing litter control.

4.7.5.3.1 Waste Placement

Initial lifts on the base of the landfill cells are made to a thickness of approximately 4.0 m to protect the liner and leachate-collection system. The initial lift is intended to both protect the

collection piping and to provide an insulating layer prior to freeze up. Final cover is placed over completed areas.

The Equipment Operator checks for prohibited or special waste during waste placement, moving, and compaction.

In order to achieve optimum densities of the waste (thereby minimizing landfill volume) while also providing a good working base, waste is spread in 300 to 600 mm thick lifts.

Normally, each working face shall be constructed to a height of 3 to 5 m and a length of 15 to 20 m, with a 4:1 slope.

4.7.5.3.2 Compaction Effort

Waste compaction is a significant factor in many aspects of landfill operations and development:

- Proper compaction is sought (e.g., Photo 1-2) as to maximize air-space utilization and provide a good working surface and stable fill mass as development progresses, thereby reducing the potential for long-term settlement.
- Inadequate compaction is avoided as this results in a loss of cover material into the waste voids.
    - Inadequate compaction can also increase differential settlement, resulting in increased use of soil to maintain final cover.
- Larger void spaces are avoided as they can contribute to landfill fires.

Landfill equipment make three to five passes to achieve optimum density.

Compactors are used to achieve higher densities by grinding and shredding the refuse into smaller pieces while climbing the slope during compaction passes. Slopes are maintained as to achieve maximum compaction.

4.7.5.3.3 Working Face Minimization

The single most powerful operational improvement outlined in the City's draft new Operations Plan (Appendix G) and arising from the City's commitment to achieving "Best Practice," is minimization of the working face. Review of the "Best Practices" review in the Phase 1 ELP (Stantec 2011f) will indicate the high extent of environmental risk factors created by excessive landfill working faces and, conversely, the great benefits achievable by their minimization. This fact is broadly recognized in the landfill design and a hallmark of Best Practice. Numerous SOPs contained in the new draft Operating Plan (Appendix G) require working-face minimization.

4.7.5.4 Cover

The site is operated as a Class I landfill, with soil or alternative cover placed as required:

- To minimize habitat for disease vectors.
- To minimize the opportunity for windblown litter to be generated from the working face.
- To provide an additional means of odour control.
- To minimize infiltration of precipitation.
- To limit the potential for the spread of fires in the event they occur.

Proper utilization of cover material is important. By maintaining a small working face and achieving proper compaction, maximum utilization of cover material can be achieved.

Effort is made to divert clean fill brought to the landfill for stockpiling for future use. Placed on top of existing fill, it also adds a loading surcharge to increase the consolidation and compaction of previously placed wastes, gaining better density of the wastes, while maximizing airspace. In so doing, it can also provide additional travel surfaces. If necessary, additional material may be required from borrow sources on-site or in the area for interim or final cover.

4.7.5.4.1 Daily Cover

Where soil is used as daily cover, the minimum thickness is 150 mm. To ensure that the daily cover soil is effective, the following procedures are followed:

- The daily cover is placed, spread and sloped to promote surface water drainage and prevent infiltration of storm water.
- On a regular basis, the landfill Foreman (or designate) inspects covered areas for erosion, exposed waste or other damage, and repairs are made as needed.

Daily cover is placed at the end of each working day. Daily cover may be removed as much as practical before subsequent waste placement the next working day.

Trial uses of synthetic (or other alternative) daily cover (for example, blown straw) may be undertaken to evaluate the potential for reducing the volume of soil required while still meeting Class I landfill cover requirements.

4.7.5.4.2 Fire Break Cover

Approximately every 50 m of tipping face advancement, the face will be covered with 150 mm to 200 mm of clay to act as a fire break.

4.7.5.4.3 Intermediate Cover

Intermediate cover is used to facilitate drainage control, to allow for equipment travel over completed areas, to prevent exposure of wastes, and to minimize the potential for wind-borne debris and water infiltration. Intermediate cover is maintained to repair erosion or cracking of the soil. The thickness of the intermediate cover is a minimum of 300 mm.

4.7.5.4.4 Final Cover

Final cover has been placed on completed landfill cells. Requirements for final cover are as follows:

- The barrier layer (~1.0 m) is clay or suitable soil or an equivalent functional alternative barrier layer. If an alternative barrier layer is utilized, a growth zone must be included.
- The barrier layer is vegetated, preferably using native species.
- Additional maintenance soil and effort may be required to remediate differential settlement.

The final surface of the landfill is graded such that water does not pool over the landfill area (e.g., slope of 30%; Figure 4-4).

The vegetated surface is managed throughout the active life of the site to minimize infiltration of water into the filled areas and to minimize contact with solid waste.

Prior to the time of cell completion, final cover areas are inspected and repaired as required.

4.7.5.5 Final Grades

Final grades shall be as per the site fill plan.

4.8 NUISANCE MANAGEMENT

4.8.1 Litter Control

Litter does not represent a significant direct threat to either human health or the environment. However, litter is unsightly, creates a nuisance and may contribute to a fire hazard. Litter escape is one of the most commonly voiced complaints about landfills. Prudent litter control assists the City to develop and maintain a good relationship with neighbours of the Brady Road landfill. The Landfill Supervisor maintains litter controls to minimize the escape of windblown litter from the Brady site and must ensure retrieval of litter that is blown onto adjacent properties or that accumulates on the Brady Road site.

Staff manage the site proactively for optimum litter control to adhere to Best Practices in this area.

4.8.1.1 Litter-Control Program

Litter is controlled at the working face by means of large movable screens around the working face, and tall permanent screens at the site periphery. Site landscaping and daily to weekly litter clean-up patrols contribute to near-real-time management of litter on-site.

The City maintains its familiarity with the latest relevant Best Practices regarding litter control. Windblown wastes are controlled by the following methods:

- Waste-transportation vehicles are required to use adequate load covers or other means of containment. The adequacy of covers or containment of incoming wastes is checked at the facility entrance.
- A minimized working face (for the volume of wastes being received for disposal), the procedure of working the wastes up-slope, and machine compaction are maintained to help reduce generation and resulting need for litter cleanup.
- Daily cover is applied as frequently as needed to assist with the control of windblown waste.
- Litter control screens are cleaned on a regular basis (e.g., when area is ~50% blinded) to retain effectiveness. This prevents airflow from traveling over the fence causing litter to escape.
- To add to current plantings, the site perimeter will be planted more aggressively, especially along the north, east and west boundaries, with concentric rings of deciduous and evergreen trees and shrubs to provide a botanical interception barrier for windblown litter that escapes the screens.
- As part of the overall site-maintenance program, facility personnel regularly collect windblown waste materials that have accumulated throughout the site; at fences and gates, and alongside on-site access roads, especially on an as required basis (e.g., immediately after storms). Following spring snowmelt and periods of high winds, additional effort is allocated to retrieve windblown litter.

The Landfill Supervisor responds to neighbour complaints in a prompt and thorough fashion. Litter complaints are documented. Reasonable and timely actions are taken to address complaints. The Supervisor considers wind speeds and directions to ensure appropriate steps are taken to contend with prevailing conditions.

4.8.2 Vector and Vermin Control

The need for vector control (e.g., deer, canines, rodents, flies, birds, mosquitoes, etc.) is minimized through site operations, which include the application of daily, intermediate, and final cover. The extent of the working face is also minimized to control vectors. As well, the entire

landfill site is securely fenced. Non-bird vector control (i.e., insects and vermin) is achieved by proper compaction and covering practices. Site operators make daily checks for problems and advise the Landfill Supervisor. Occasionally live trapping of wildlife can occur when appropriate. If necessary, a licensed professional is retained to apply vector-control products to ensure that proper chemicals are used and that they are properly handled.

4.8.2.1 Bird Control

The need for bird control is minimized through operations, which include the application of daily, intermediate, and final cover. The extent of the working face is also minimized to control birds.

Because the facility is aligned with the southern approach to the Winnipeg International Airport, large permanent ponds are discouraged on-site to reduce attraction to migratory birds, or will be designed and operated to minimize bird attraction and/or to function as “dry ponds.”

Appropriate harassment techniques are used to move birds away from the working face and to deter birds from taking up permanent residence on the site. From time to time and as appropriate, staff retain the services of professional falconers using trained birds of prey to scare and remove unwanted bird species from the site. This technique relies on the natural predator-prey relationship that exists between raptors and other bird species.

4.8.3 Odour Control

Emissions from the working face are distinctive and unpleasant. The greatest sources of these emissions are organics in the waste mass. Wastes with strong odours are typically placed at the toe of the working face and immediately covered with other garbage or daily cover. The application of daily cover at the end of the working day also helps control odour. The current trial using chopped blown straw for daily cover is also proving to be helpful.

Special attention is given to wastes which are known to be likely sources of odour problems. Such wastes include, but are not limited to: dead animals, waste from food processing facilities, dewatered biosolids and treatment plant grit screenings. Odour management is sought by adherence to the following prescriptions:

- Weighmaster’s identification of loads with significant odours and immediate advice to workface personnel to allow the waste's prompt disposal at the working face and its immediate cover with other waste (or earthen material).
- Prompt landfilling of incoming waste.
- Minimizing the size of the working face.
- Control of ponded water at the site.

- Regular inspection and repair of damaged leachate-system components.
- Prompt repair of damaged or eroded daily, intermediate, or final covers.
- Landfill gas-system.

Biosolids which are currently all being landfilled can be a source of odour. Since 2009, the City has been examining various options for dealing with this material (including composting some of the material at the landfill; Tetr*ES* Consultants, 2009a, b), pending a longer-term solution. Current examinations by the City (jointly with Veolia Water Canada Inc.) include consideration of the greenhouse gas emissions potential of different biosolids-management options (Stantec, 2011b).

Regular odour monitoring around the entire periphery of the site will soon be carried out and the data recorded in the Operating Log. All 311 odour complaints are responded to as quickly as possible and the response is noted in the log. Regular inspections will occur to identify cracks and fissures in the landfill cover. Cracks and fissures will be repaired with soil to prevent the release of odours.

4.8.4 Noise Control

Noise is not a significant issue largely because of separation distance from adjoining homes. Operations are confined to posted open hours to minimize noise. Proper maintenance of equipment occurs to also help limit noise levels. Continuous and other on-site tree screens and berms can also minimize the potential for site noise to trouble neighbours. Road maintenance and enforcement of on-site speed limits also limit traffic noise.

4.8.5 Mud and Dust Control

Accumulation of mud during inclement weather is limited to the vicinity of the active fill area. On-site roads are constructed of a crushed/recycled glass or crushed rock base and a gravel surface. Accumulated mud is typically thrown from tires before vehicles reach public roadways. On days in which mud from tires extends outside of the gate house, the Foreman inspects public access roads for tracked mud.

Fugitive dust emissions are minimized through proper operating procedures which include spraying site roads with uncontaminated surface water or dust suppressants.

Use of wind screening, site vegetation, a limited working face, proper waste-placement procedures, and progressive closure of completed landfill areas all help to limit dust entrainment. Vehicles entering the site are speed restricted to avoid producing excess amounts of airborne dust or suspended particulate matter.

4.9 MONITORING

4.9.1 Leachate Monitoring

Leachate at the facility is monitored for quality and quantity. Leachate-chemistry monitoring assists in determining the constituents of the leachate, which is required to be known by the NEWPCC treatment-facility operators to ensure the chemical/contaminant loads can be handled by the treatment system (i.e., supports leachate treatability). Leachate-quantity monitoring assists in tracking the amount of hydraulic head or water pressure on the liner and informs the leachate-pumping program. The quantity of leachate in sump manholes is monitored monthly, or less frequently as indicated by conditions.

Currently, in addition to daily load grab samples collected for the NEWPCC, qualitative samples are collected on an annual basis from the leachate sumps. Since 2007, the quantity of leachate or leachate levels has been monitored quarterly, or at least bi-annually.

4.9.2 Landfill Gas Monitoring

As the LFG project progresses, additional landfill-gas monitoring wells will be installed to facilitate better monitoring of gas composition from the completed and capped portion of the landfill.

Landfill gas is produced from the decomposition of readily degradable organic waste. Landfill gas is composed of a mixture of different gases. In wet wastes, hydrogen sulfide is produced from anaerobic decomposition of high-sulphide wastes (e.g., “Gyproc” wallboard) that are present. Table 4-4 lists “typical” landfill gases, their percent by volume, and their characteristics.

Table 4-4: Typical Landfill Gas Components

Component	Percent by Volume	Chemical and Physical Characteristics
Methane	45-60	Methane is a naturally occurring gas. It is colourless and odourless. Landfills are the single largest source of U.S. manmade methane emissions.
Carbon dioxide	40-60	Carbon dioxide is naturally found at small concentrations in the atmosphere (0.03%). It is colourless, odourless and slightly acidic.
Nitrogen	2-5	Nitrogen comprises approximately 79% of the atmosphere. It is odourless, tasteless and colourless.
Oxygen	0.1-1	Oxygen comprises approximately 21% of the atmosphere. It is odourless, tasteless and colourless.
Ammonia	0.1-1	Ammonia is a colourless gas with a pungent odour.

Table 4-4: Typical Landfill Gas Components		
Component	**Percent by Volume**	**Chemical and Physical Characteristics**
NMOCs (non-methane organic compounds)	0.01-0.6	NMOCs are organic compounds (i.e., compounds that contain carbon). (Methane is an organic compound but is not considered an NMOC.) NMOCs may occur naturally or be formed by synthetic chemical processes. NMOCs most commonly found in landfills include acrylonitrile, benzene, 1,1-dichloroethane, 1,2-cis dichloroethylene, dichloromethane, carbonyl sulfide, ethylbenzene, hexane, methyl ethyl ketone, tetrachloroethylene, toluene, trichloroethylene, vinyl chloride and xylenes.
Sulfides	0-1	Sulfides (e.g., hydrogen sulfide, dimethyl sulfide, mercaptans) are naturally occurring gases that give the landfill gas mixture its "rotten-egg" smell. Sulfides can cause unpleasant odours even at very low concentrations.
Hydrogen	0.0.2	Hydrogen is an odourless, colourless gas.
Carbon monoxide	0.0.2	Carbon monoxide is an odourless, colourless gas.
Source: Tchobanoglos, Theisen and Vigil 1993; EPA 1995 Source: http://www.atsdr.cdc.gov/HAC/landfill/PDFs/Landfill_2001_ch2mod.pdf		

Landfill-gas monitoring occurs annually, but will soon occur on a quarterly basis, at minimum. Methane concentration levels are measured in the subsurface at the property boundary, in any on-site buildings and in off-site buildings close to the property boundary. Vegetation in final and intermediate cover and surrounding areas is inspected for signs of stress due to gas emissions from cracks in the underlying cover. Monitoring records will be included in the Operating Log.

4.9.3 Groundwater-Monitoring

4.9.3.1 Network Design

The groundwater-monitoring network at the Brady Road Landfill consist of five piezometer (i.e., monitoring well) nests containing from four to six wells to various depths in each well nest, screened in the overburden, and eight individual bedrock wells (Figure 4-9). All groundwater-monitoring wells are capped and locked.

Well sizes range from small 1" diameter wells to larger 5" diameter wells. Many of the wells have dedicated Watera pumps or submersible pumps in the larger boreholes.

Any additional monitoring wells that may be needed will be placed strategically and installed as required with expansion of the facility as approved or required by Manitoba Conservation.

BRADY ROAD LANDFILL

LEGEND

▲ OVERBURDEN PIEOZOMETER NEST
⬢ GROUNDWATER WELL

0.0 0.05 0.1 0.2 0.3 0.4 0.5
DISTANCES IN KM

B.M. ELEV.		FIELD BOOK #:	
POSTED TO LBIS			
1		11/11/25	KB
NO.	REVISIONS	DATE	BY

Winnipeg

THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT

BRADY ROAD LANDFILL

WELL LOCATIONS

SHEET 1 OF 1

FIGURE 4-9

4.9.3.2 Program Design

Groundwater sampling started in 1986 at the Brady Landfill. Between 1996 and 2009, the monitoring was sporadic; not all wells were sampled in each sampling campaign, and sampling did not occur every year. Since 2009, the City has established an annual frequency of groundwater monitoring similar to the frequency recommended by the Ontario guidelines and as currently in place at the BFI landfill.

The wells are purged to dryness and sampled several days later, or are purged at a rate of 3X volume and sampled immediately. Analysis is carried out by the recently-accredited City of Winnipeg lab. Samples are also sent to other accredited labs for analysis if the City of Winnipeg lab is experiencing delays.

In November of 2009, the City installed dataloggers for continuous monitoring of groundwater elevations in different geological strata.

4.9.3.3 Data Management and Integration

The following information is recorded:

- The place, date and time of sampling
- The dates the analyses were performed
- The analytical techniques, methods or procedures used in the analysis
- The names of the persons who collected and analyzed each sample
- The results of the analyses

Monitoring results are maintained indefinitely in summary tables and data files, which are interpreted in various reports.

4.9.4 Surface-Water Monitoring

Surface-water monitoring is currently undertaken semi-annually (spring and fall) at an ‘upstream’ location at the Brady Road municipal roadside ditch west of the facility and the ‘discharge’ location on the northeast side of the facility towards the Westendorf Coulee (Figure 4-1). This program has been in place since 2008. ‘Downstream’ surface-water monitoring locations were recently established downstream on the Westendorf Coulee, at the La Salle River and at the Red River. Monitoring may also occur after passage through a proposed new wetland to “polish” site runoff (Figure 1-1) at a V-notch weir or similar sampling device (Photo 4-1). Surface-water samples are typically analyzed for a wide variety of water-quality parameters.

4.10 SAFETY AND EMERGENCY RESPONSE

4.10.1.1 Landfill Fire

A landfill fire is one of the most serious situations that can occur at a waste-management facility. The required effort to extinguish a fire can be substantial, including major excavation of wastes and cover until the fire is isolated.

Although fires are not permitted as part of normal landfill operations at the facility, accidental fires can occur, particularly at the working face. Fires are typically attributable to wastes delivered with hot embers (“hot load”). Fires can also result from reactions within the waste, such as decomposing grass clippings or spontaneous combustion of oily rags. At Brady Road, the largest fires have arisen from lightning strikes (Hawley, *pers. comm.,* 2010a).

To reduce the possibility of fire, smoking is not permitted at the active landfill area or at the recycling facility or storage sites.

Fire within a landfill cell is dealt with as follows:

- Excavating the smoldering or burning wastes with heavy equipment such as the packer, bulldozer or excavator.
- Placing smoldering waste in an area away from the working face and other combustible materials.
- Spreading and covering the excavated smoldering waste with soil.
- Avoiding excessive use of water to extinguish the fire as soil is usually more effective; however, if water is required, the on-site water is used to wet down the area.

Care is taken to avoid equipment catching fire.

In the event that on-site equipment is unable to control a landfill fire quickly, the City Fire Department must be called for assistance. To Stantec’s knowledge, such mobilization of the Fire Department to the landfill has occurred only once, and only as a precaution (i.e., no active firefighting by the department; Hawley, *pers. comm.,* 2010b).

4.10.1.2 Fire Prevention Plan

Employees receive initial and annual training regarding the procedures required for fire prevention. The following steps are taken regularly by designated landfill personnel to prevent fires:

- Burning waste is prevented from being dumped at the working face. The weighmaster and equipment operators check for signs of burning waste (e.g., smoke, steam, or heat being released from incoming waste loads).
- Fuel spills are contained and cleaned up immediately.
- Personnel are forbidden to smoke on the active areas of the landfill.
- Soil of sufficient quantity to cover the working face is stored beside the working face of the active disposal area for fire suppression.
- All on-site structures and heavy equipment are fitted with appropriate fire extinguishers.

4.10.2 Contingency Response Plan

A new Emergency Response Plan (ERP) for the Brady Road Landfill Facility is currently under development. The Plan is being developed generally in accordance with the Canadian Centre for Occupational Health and Safety planning guidelines. The ERP will be submitted to the Director of the Manitoba Conservation Environmental Assessment and Licensing Branch within three months following the *Environment Act* licence issue date.

The Emergency Response Plan will identify potential unforeseen emergencies and response actions including, but not limited to, alarm activation, response procedures and reporting requirements. The Plan will also outline required training, including drills and exercises, for emergency preparedness.

4.11 RESEARCH AND DEVELOPMENT

The City has engaged, for many years, in ongoing scientific and engineering studies of landfill performance to support either new design processes or to provide data on the effectiveness of landfill designs. This has included various studies contracted to private-sector firms and the academic community. A number of reports noted in Section 11 arise from the City's commitment to support of ongoing research and development.

A key component of the development to be licensed is the City's commitment to ongoing scientific and engineering investigation. Among the various subjects which the City intends to continue investing in are the following:

- Longer-term assessment of operational effectiveness of the landfill-gas recovery project.

- Long-term analysis of rates of leachate movement beneath previous completed cells of the landfill, and surveillance of leachate movement in all new cells designed to the Best Practices standard of care.

- Long-term optimum management of biosolids.

- New means for increased surveillance of subsurface subsidence, oxygen ingress or other factors contrary to effective landfill performance.

- Effectiveness of airspace management.

- Longer-term full-cost accounting of landfill design and operating effectiveness.

- Technical and economic issues associated with landfill mining.

  – Insight from such studies can greatly assist the City's long-term planning for almost three dozen completed landfills distributed across the City (City drawing No. SWD-D-97A and City file DATA/SPREADSHEET/LANDFILL/SITINST2.WBZ).

Typically, the City has encouraged landfill-related studies by supporting graduate students (and undergraduate students) at the University of Manitoba, Faculty of Engineering. It is contemplated that this approach will continue in the years to come and be expanded to include other centres of learning (e.g., Red River College, University of Winnipeg, Brandon University).

4.12 PUBLIC DISCLOSURE AND ACCOUNTABILITY

The City, in undertaking development of the CIWMP, engaged in a vigorous program of public consultation. Public views and sentiments were recorded in a number of ways, and study findings, and public comments, were regularly uploaded to the City's website to facilitate public disclosure.

The City is mindful of the public interest in the effectiveness of landfill operations. Notwithstanding public support for the planned improvements at the landfill, as expressed at the October 27, 2011 Public Meeting (Section 6), the City is committed to improved communication of information about landfill operations, particularly:

- The ongoing effectiveness in encouraging diversion of recyclable materials from the waste streams being delivered to the landfill.

- Information on new materials-recovery processes and their effectiveness.

- Information about business opportunities identified by local entrepreneurs seeking to engage with the City in materials recovery, repurposing and commoditization.

- Leachate, landfill gas, groundwater and surface water monitoring reports.

The City is committed to forms of public accountability that are “user friendly,” and which can be accessed by a wide variety of audiences. Corporate Sustainability Reporting (CSR) initiatives in the private sector have created many tools amenable to such accountability, including those created by the Global Reporting Initiative (GRI; www.globalreporting.org).

The City will consider such tools and will select a mechanism for ongoing public accountability reporting, likely a web-based tool.

5.0 Site Description

The following sections set out information about the attributes of the site and surrounding region that have potential to either encourage, or prevent, impacts from landfill operations.

5.1 BIOPHYSICAL CHARACTERISTICS

5.1.1 Regional Geology and Hydrogeology

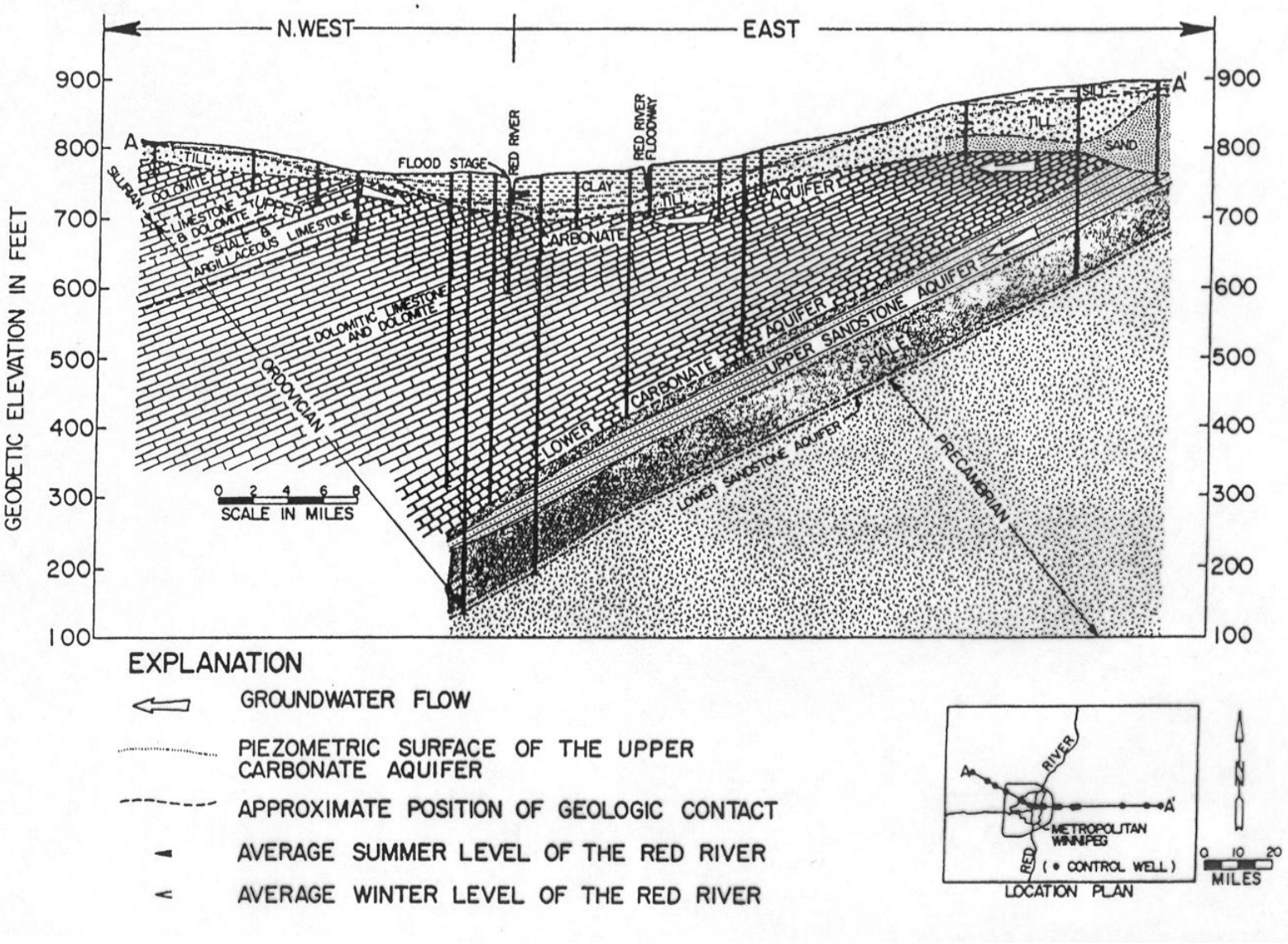
The study area is located on the eastern edge of the Western Canada Sedimentary Basin (WCSB) which dips gently toward the southwest and pinches out to the east of the Winnipeg, where the Canadian Shield granitic terrain begins (Figure 5-1). In the Winnipeg area, the bedrock of the WCSB belongs to the Paleozoic Era and is covered by glacial deposits averaging 20 m in thickness (Render, 1970; Baracos *et al.,* 1983). Paleozoic rocks are generally carbonates with minor clastics and evaporites, and have a total thickness of approximately 150 m. Two hydrostratigraphic units have been identified within this Paleozoic bedrock (Simpson *et al.,*1987; Betcher *et al.,* 1995):

- The Basal Clastic Hydrostratigraphic Unit, which includes Cambrian and Ordovician sandstones and shales. The sandstone aquifers in these formations are separated from the overlying carbonate rocks by an upper shale.

- The Carbonate-Evaporite Hydrostratigraphic Unit, which consists of Paleozoic carbonates with minor shales, sandstones and evaporites.

In the Basal Clastic Unit, most of the local groundwater comes from the Winnipeg Formation sandstone aquifer. This aquifer is overlain by the Carbonate-Evaporite Hydrostratigraphic Unit containing the so-called “upper” and “lower” carbonate aquifers in Winnipeg the area (Figure 5-1). In the sandstone and carbonate aquifers, groundwater flows towards to the central part of Winnipeg due to significant withdrawal groundwater and natural recharge to the Red River. Groundwater in the upper carbonate aquifer is generally fresh to the east of the Red River and brackish and saline to the west, whereas the salinity in the sandstone aquifer progresses further east beyond the city limits (Ferguson *et al.,* 2007). Bedrock aquifers receive fresh recharge from coarse overburden deposits directly overlaying the sandstone and carbonate units north-east of Winnipeg.

Regional overburden consists of Pleistocene glacial and lacustrine deposits. In the Winnipeg area, there are two units in the overburden: a sandy-silty till averaging 6 m in thickness, which is overlain by glacial clay unit approximately 12 m thick (Baracos *et al.,* 1983). The upper portion of the clay unit is weathered and fractured, while fractures in the lower portion of the unit, and in the till, are rare but have been documented (Day, 1977; Cherry and Smith, 1990; Pach, 1994). There are no significant freshwater aquifers present in the overburden in the Winnipeg area.



Source: Barcos et al, 1983 (after Render 1970)

Hydrogeological Cross Section of the Red River Valley Through Winnipeg

Figure 5-1

5.1.1.1 Site Stratigraphy

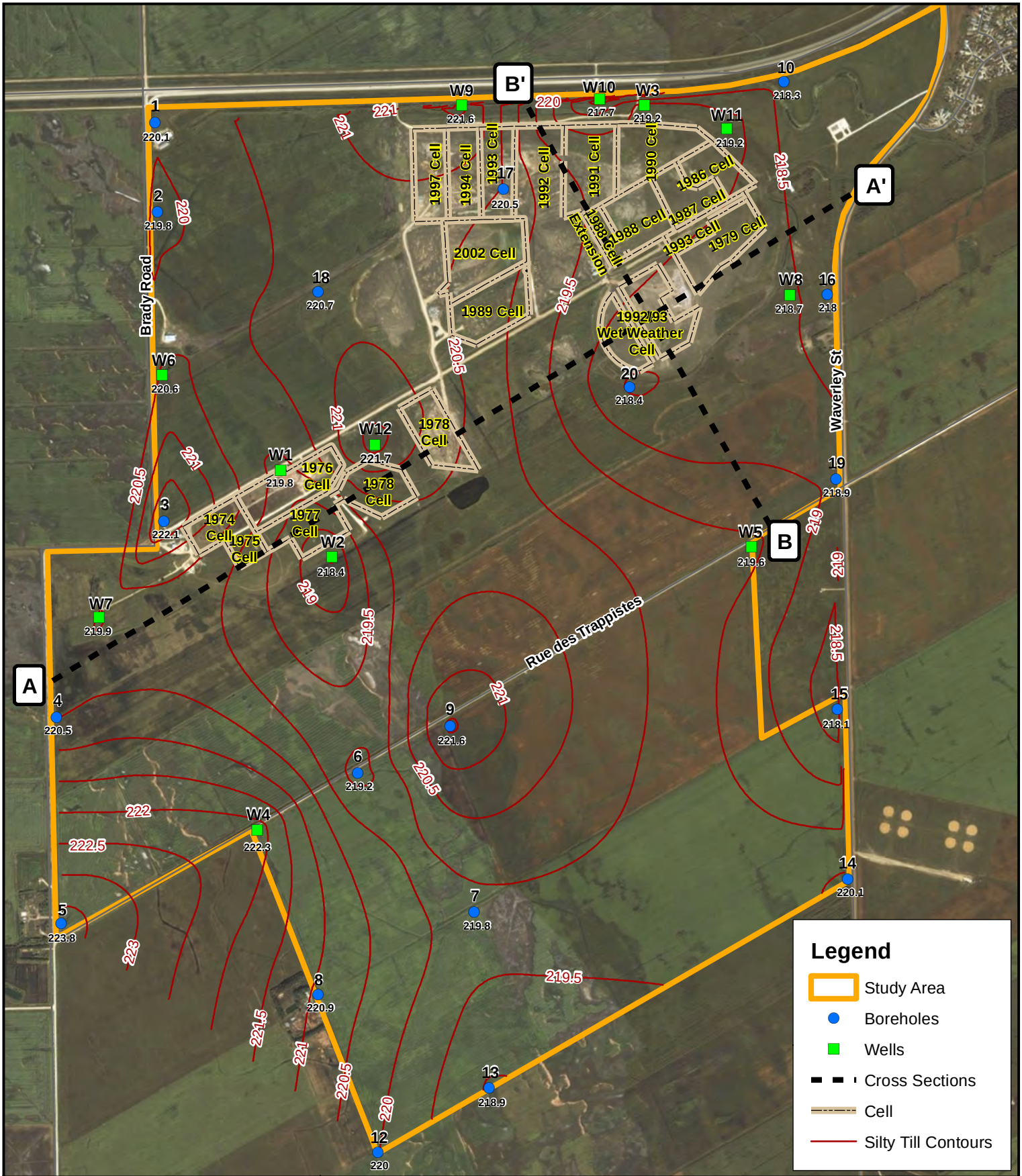
Understanding of site stratigraphy is based on a 1987 UMA study for the City of Winnipeg and recent borehole logs completed by the City. In total, 31 borehole logs were considered suitable for interpolation (Figure 5-2). The 'natural neighbor' interpolation technique was used to produce contours of stratigraphic surfaces.

The upper stratigraphic unit beneath the landfill is glaciolacustrine clay, varying in thickness between 11 and 16 m with average value of 13.8 m. Weathered olive-brown clay is found in the upper 5-8 m of the unit and is referred to as "brown clay" (Figures 5-3 and 5-4). The lower portion of the clay unit has grey color. Numerous silt pockets and gypsum clusters are present in the clay. Some relevant physical properties of the clay are summarized in Table 5-1.

Table 5-1: Summary of Physical Properties of the Overburden Strata

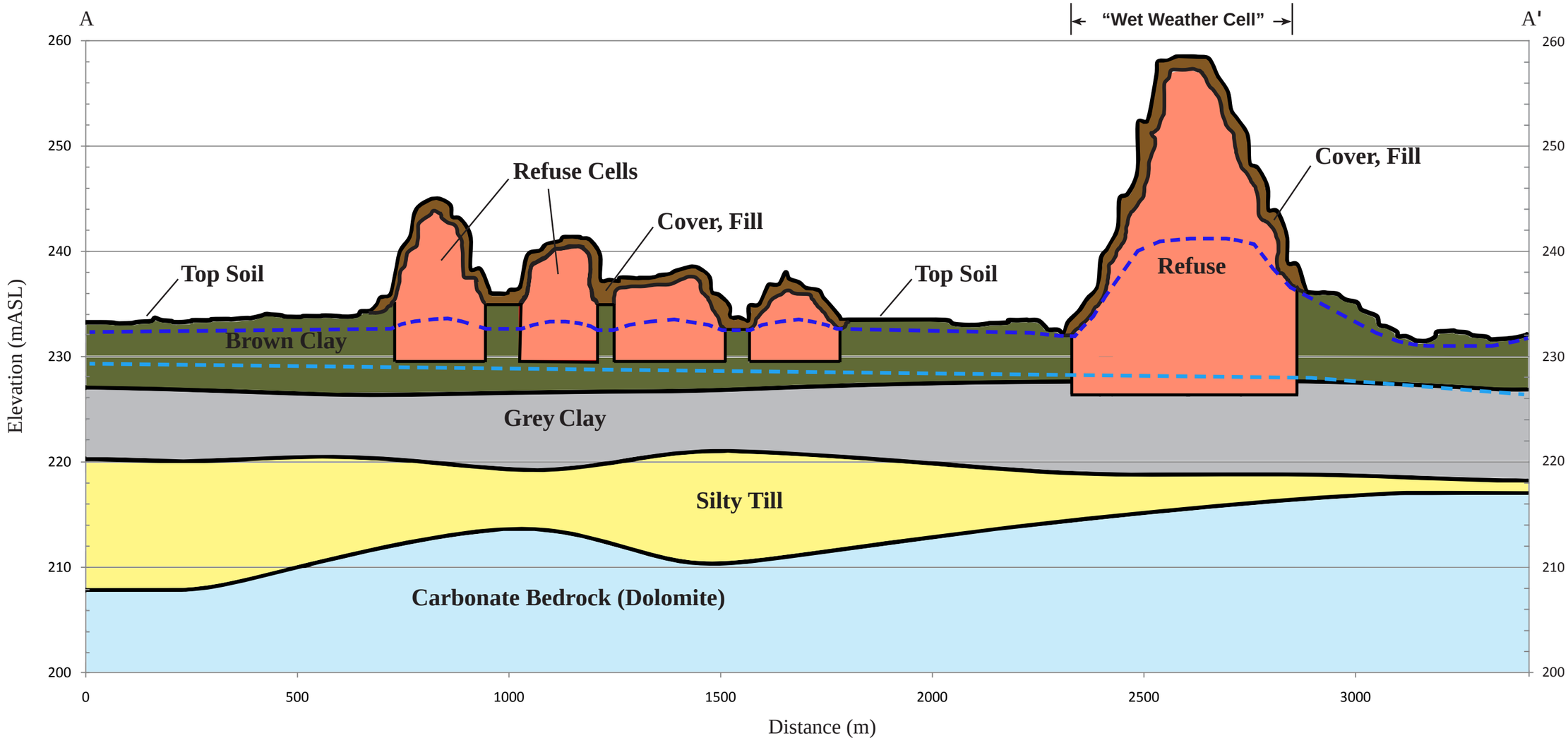
	Brown Clay	Grey Clay	Silt Till
Moisture Content (%)			
Minimum	21.4	34.4	--
Average	44.6	52.5	--
Maximum	56.3	59.8	--
Bulk Density (g/cm^3)			
Minimum	1.66	1.65	--
Average	1.71	1.72	--
Maximum	1.79	1.79	--
Plasticity Index			
Minimum	34.6	34.6	--
Average	51.3	43.0	--
Maximum	60.6	54.4	--
Field Hydraulic Conductivities (m/s)			
Minimum	2.3E-10	1.9E-10	2.7E-09
Average	3.6E-09	3.4E-10	4.1E-08
Maximum	1.0E-08	5.5E-10	1.3E-07
Source: UMA 1987			

The clay unit overlies a silty till of grey color. The elevations of the silty till surface are shown on Figure 5-2. The thickness of the silty till ranges from 1.5 to 13 m, with an average value of



Silty Till Surface Elevations

Figure 5-2



Approximate position of perched water table (summer-fall 2008)
Piezometric water level in the bedrock (summer 2009)

Horizontal Scale = 1:10,000 (1cm:100m)
Vertical Scale = 1:400 (1cm:4m)

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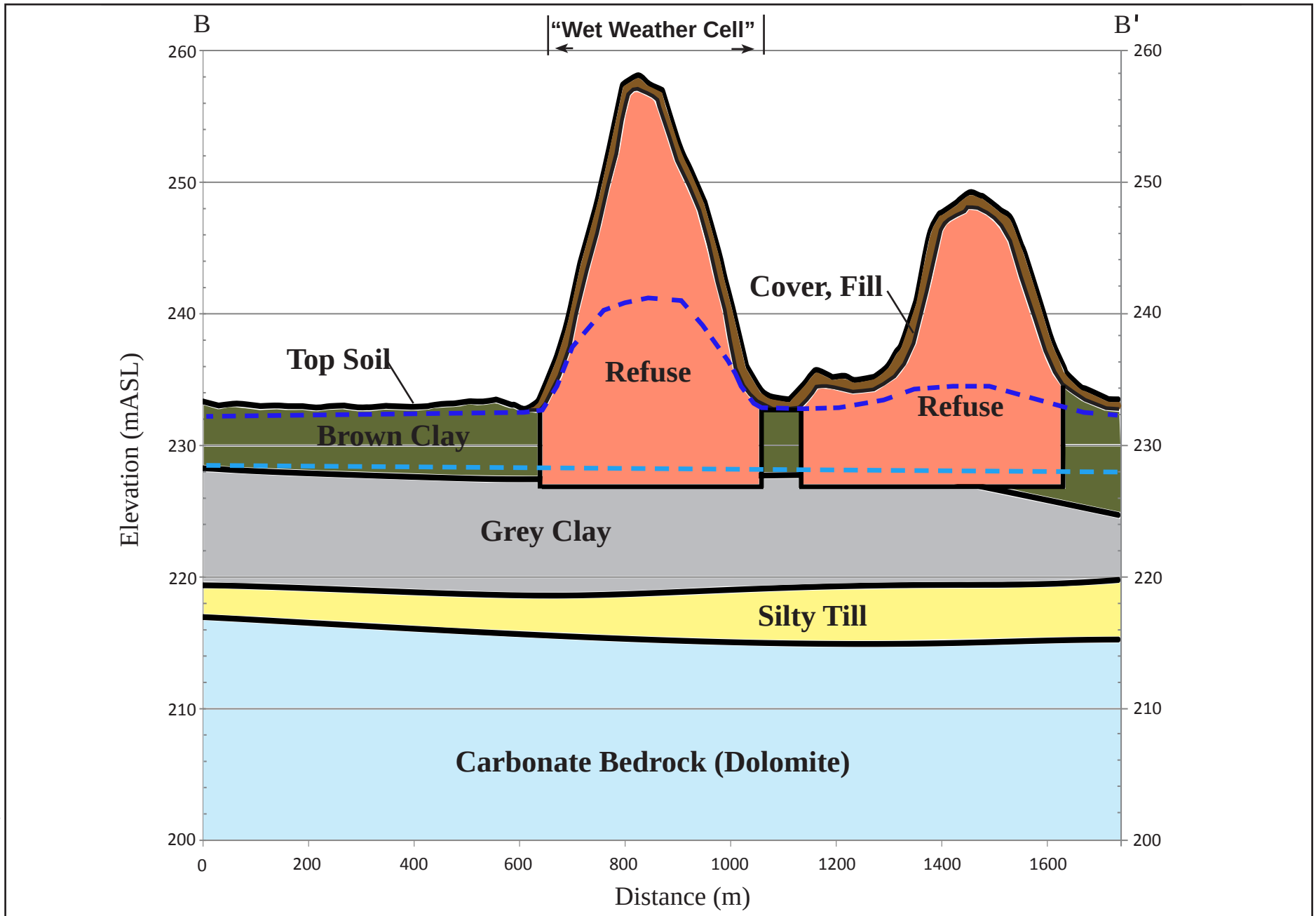
Cross Section AA

Figure 5-3



Approximate position of perched water table (summer-fall 2008)

Piezometric water level in the bedrock (summer 2009)

Horizontal Scale = 1:10,000 (1cm:100m)

Vertical Scale = 1:400 (1cm:4m)

Cross Section BB

Figure 5-4

5.8 m. Geological cross-sections show that the till layer thins from south-east to northeast (Figures 5-3 and 5-4). Cobbles and rubble have been documented at the base of the till.

The overburden is underlain by bedrock – white dolomitic limestone of the Red River Formation of Ordovician age. The bedrock surface is uneven and can be found from 16 to 29 m below the ground (Figure 5-5). Numerous fractures, some caverns and other karst features are reported in the bedrock hosting an aquifer.

5.1.1.2 Hydrogeology

Groundwater levels are monitored at different strata below the site at least twice a year by City personnel using bedrock wells and nested piezometers completed in the overburden. In addition, pressure transducers installed in wells W5, W9,W10 and W11and in piezometers 4N43C and D provide for continuous monitoring of groundwater levels (Figure 5-2, Table 5-2).

5.1.1.2.1 Directions of Lateral Movement and Aquifer Transmissivity

In the bedrock aquifer, groundwater flows in a north-east direction according to piezometric levels (Figure 5-6). Hydraulic gradients range from 0.0003 to 0.002 with average value of 0.0007. The horizontal gradient in the aquifer increases from south-east to north-east. Seasonal changes in groundwater levels can vary up to 2.5 m in the aquifer (Figure 5-7). There is a long-term trend showing an increase of groundwater levels in the aquifer (Figure 5-8). Since 1990, the levels have increased at least 2 m in all bedrock-monitoring wells. There is no vertical gradient across the upper 30 m of bedrock. According to UMA (1987), the expected transmissivity of the aquifer should be around 0.014 m^2/s.

5.1.1.2.2 Hydraulic Conductivities

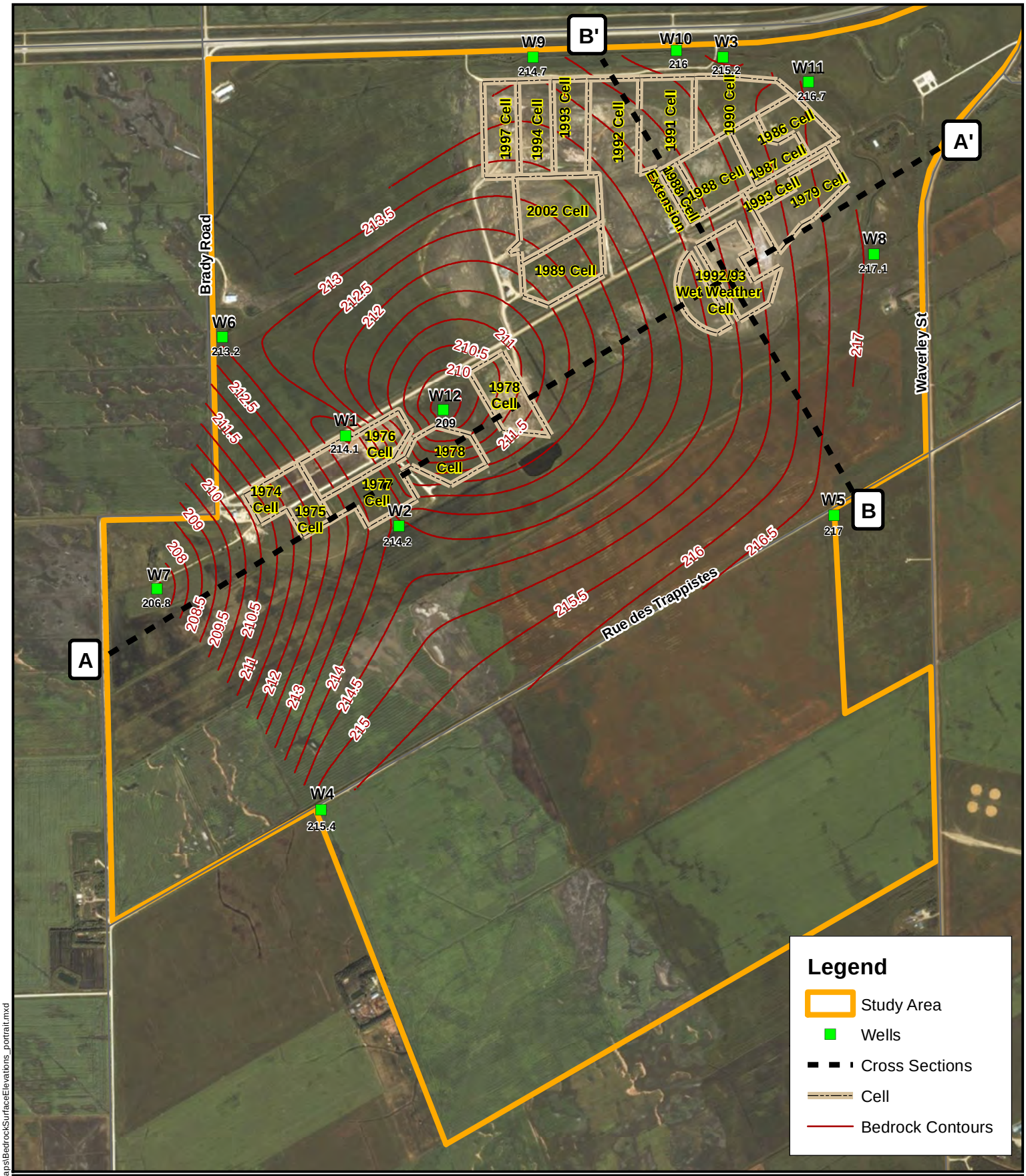
The silty till and the bedrock generally have similar piezometric levels, indicating hydraulic connection between these strata (Table 5-2). Hydraulic conductivities of the silty till range from $2.7x10^{-9}$m/s to $1.3x10^{-7}$m/s with average value of $4.1x\ 10^{-8}$ m/s (UMA, 1987). Variability in till thickness and a wide range of hydraulic conductivities results in a complicated flow pattern under the site, which likely has both horizontal and vertical components.

5.1.1.2.3 Vertical Movement and Velocities

In the clay unit, water levels are approximately 4 m higher than in the aquifer, indicating a preferential downward movement of groundwater within clay (Figures 5-3 and 5-4). According to UMA (1987) field tests, average hydraulic conductivities are $3.6x10^{-9}$m/s and $3.4x10^{-10}$ m/s for the brown and grey clays, respectively. Brown clay has larger variability in hydraulic conductivity than grey clay, possibly due to frequent fractures in the brown clay (Table 5-1). UMA used D'Arcy's law to estimate the range of vertical advective transport in the clay unit, in consideration of vertical hydraulic gradients across the unit, porosity values ranging from 0.25 to 0.45, and average field permeability at each site. Estimated vertical velocities ranged of from

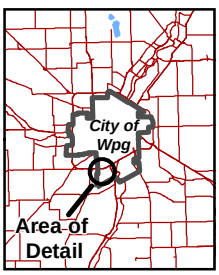
Table 5-2: Piezometric Water Levels in Bedrock and Overburden in Mid-summer 2009										
Well ID	UTM Coordinates, NAD83		Top of Casing Elevation, mASL	Ground elevation, mASL	Depth to water, m	Groundwater elevation, mASL	Date	Screen (m, below grade)		Stratum
	Northings	Eastings						top	bottom	
4N34A	5512701.3	629301.3	234.574	233.719	1.52	233.05	7-Jul-09	3.1	4.6	brown clay
4N34B	5512700.0	629299.6	234.489	233.664	0.92	233.57	7-Jul-09	7.6	9.1	grey clay
4N34C	5512702.2	629302.7	233.43	234.25	1.49	231.94	7-Jul-09	12.2	13.7	grey clay
4N34D	5512702.2	629302.7	234.344	233.573	1.32	233.02	7-Jul-09	15.3	16.7	silty till
6N57A	5514335.3	630422.0	not in service			-	6-Jul-09	2.9	4.5	brown clay
6N57B	5514333.4	630421.2	233.667	233.157	2.28	231.39	6-Jul-09	5.4	6.9	brown clay
6N57C	5514333.9	630418.9	233.646	233.19	3.22	230.43	6-Jul-09	6.8	8.5	grey clay
6N57D	5514336.0	630419.6	233.65	233.202	5.63	228.02	6-Jul-09	9.9	11.3	grey clay
6N57E	5514331.4	630421.8	233.61	233.195	6.80	226.81	6-Jul-09	13.3	14.5	silty till
6N57F	5514331.4	630421.8	233.61	233.195	6.80	226.81	6-Jul-09	14.8	16.0	silty till
W10	5514353.6	630257.2	233.842	232.902	6.30	227.54	26-Jun-09	19.8	22.3	bedrock
6N58A	5511719.3	629023.0	234.393	234.026	1.69	232.70	13-Jul-09	3.1	4.6	brown clay
6N58B	5511721.2	629022.5	234.418	234.034	1.56	232.86	13-Jul-09	4.7	6.1	grey clay
6N58C	5511718.8	629020.5	234.334	233.995	2.54	231.79	13-Jul-09	7.7	9.2	grey clay
6N58D	5511721.5	629020.4	234.474	234.008	4.54	229.93	13-Jul-09	9.4	11.1	grey clay
6N58E	5511720.7	629027.2	234.158	233.953	4.98	229.18	13-Jul-09	14.2	16.1	silty till
6N58F	5511720.7	629027.2	234.158	233.953	4.98	229.18	13-Jul-09	16.8	18.0	silty till
W4	5511722.8	629025.1	234.298	234.003	5.17	229.13	29-Jun-09	18.3	21.3	bedrock
6N59A	5512746.1	630802.2	233.612	233.233	1.19	232.42	7-Jul-09	2.8	4.3	brown clay
6N59B	5512744.8	630801.0	233.663	233.263	2.04	231.62	7-Jul-09	5.5	6.8	grey clay
6N59C	5512746.1	630799.5	233.741	233.285	2.56	231.18	7-Jul-09	7.7	9.2	grey clay
6N59D	5512747.9	630801.1	233.713	233.206	1.29	232.42	7-Jul-09	10.7	12.2	grey clay
6N59E	5512742.5	630800.3	233.663	233.255	5.43	228.23	7-Jul-09	13.0	14.6	silty till
6N59F	5512742.5	630800.3	233.663	233.255	5.37	228.29	7-Jul-09	15.2	16.7	silty till
W5	5512742.5	630802.8	233.64	233.259	5.52	228.12	29-Jun-09	16.8	29.6	bedrock
6N60A	5513357.6	628679.2	234.208	233.671	1.05	233.16	7-Jul-09	3.1	4.6	brown clay
6N60B	5513358.5	628681.4	234.109	233.684	1.49	232.62	7-Jul-09	5.5	7.0	grey clay
6N60C	5513359.6	628678.9	234.277	233.554	2.78	231.50	7-Jul-09	7.9	9.4	grey clay
6N60D	5513360.4	628681.3	234.086	233.625	2.18	231.91	7-Jul-09	10.4	11.9	grey clay
6N60E	5513359.0	628684.0	234.332	233.525	5.57	228.76	7-Jul-09	15.0	16.5	silty till
6N60F	5513359.0	628684.0	not in service			-	7-Jul-09	-	-	silty till
W6	5513361.3	628683.7	234.071	233.611	5.56	228.51	6-Jul-09	21.0	31.1	bedrock
W1	629110.0	5513018.6	not in service			-	-	-	-	bedrock
W2	629295.3	5512706.4	not in service			-	-	-	-	bedrock
W3	630418.6	5514331.8	not in service			-	-	-	-	bedrock
W7	5512489.3	628456.4	235.774	235.296	6.71	229.06	29-Jun-09	29.9	42.1	bedrock
W8	5513649.1	630941.1	233.599	232.968	6.72	226.88	7-Jul-09	17.1	23.8	bedrock
W9	5514332.1	629760.7	234.406	233.363	6.30	228.11	26-Jun-09	20.7	23.2	bedrock
W11	5514246.3	630715.1	234.028	232.949	7.59	226.44	26-Jun-09	19.8	22.9	bedrock

Source: The City of Winnipeg (*pers comm.* 2010)



Interpolated Bedrock Surface Elevations

Figure 5-5



NORTH

0 125 250 500

Metres

Acknowledgements:
Data provided by Government of Manitoba, ESRI, City of Winnipeg, Stantec Consulting Ltd.
Projection: NAD83 Zone 14N

PREPARED BY

Stantec

MAP SCALE	PROJECT
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DATE	
March 2, 2011	

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