# TSB NEWSLETTER

TECHNICAL STANDARDS BRANCH VOLUME 2, ISSUE 1, FEBRUARY 2003


## Editor's Remarks

Safety and new technologies are the main themes in this issue of the newsletter. In the *Wildlife/Vehicle Countermeasures* article, you will learn about some of the past and current practices deployed and what future technologies may be available to mitigate the problem. It is a timely topic as the department is about to initiate a joint task force on animal/vehicle collisions with Fish and Wildlife of Alberta Sustainable Resource Development. New winter maintenance technologies that deal with salt management and environmental concerns are discussed in two other articles. As you will appreciate after reading the *Pre-Wetting* and the *Road Weather Information Systems (RWIS)* articles, there is more science behind the lumbering snowplows than meets the eye. Rounding out the new technologies include an article on a bridge innovation example – long-span precast NU (Nebraska University) girders, and an article on high-tech prospecting using *High Resolution Airborne Magnetics (HRAM).*

If you recall from the October issue of the newsletter, Tim Hawnt mentioned that the department was sponsoring the First Annual Collaborative Research Forum along with the cities of Edmonton and Calgary. The all-day event took place this January 30 in Edmonton and it was deemed to be a resounding success by the participants. The central theme was on "pavements" and the agenda included topics on pavement maintenance, performance, design and QA/QC[1] issues. If you wish to see the full presentation material, please check with Sal Hasham or Terry Willis. Already, we are contemplating another forum on a different topic, so you "techies" out there get ready to contribute and participate!

**Allan Kwan**
**Editor-in-Chief**

IN THIS ISSUE



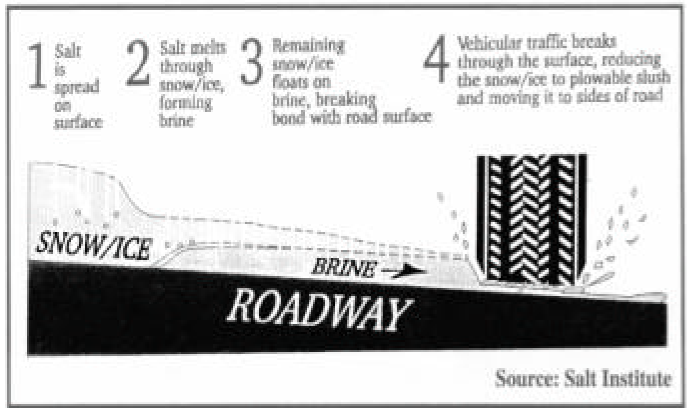
1. Quality Assurance/Quality Control

# PRE-WETTING
## Nick Bucyk

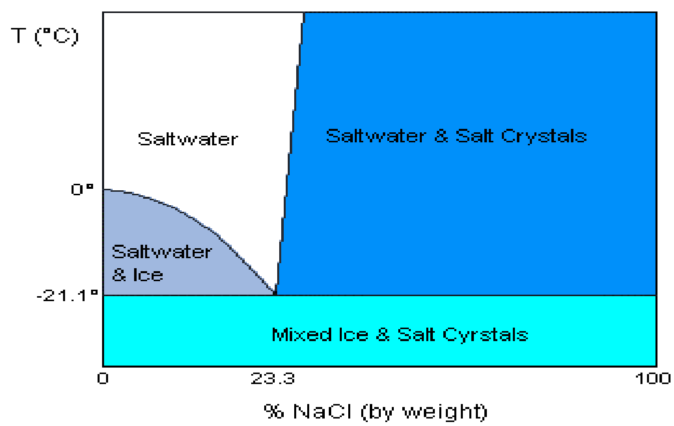
Alberta Transportation spends approximately $75 million annually on snow and ice control for the provincial highways, of which $22 million is spent on sand and salt. Not only are material costs a major expenditure of the winter maintenance budget, but environmental concerns expressed by Environment Canada have also added pressure for the department to look at ways to reduce salt usage. (http://www.trans.gov.ab.ca/Content/doctype256/production/newsltrmay02.pdf).

In 2000, Volker Stevin Contracting approached the department to use a plow truck equipped with pre-wetting equipment on a trial basis in the Lethbridge area. The success from this first winter's pre-wetting trial prompted an expansion in 2001 to include other maintenance contract areas. As a result, the department has now incorporated into the new maintenance contracts the requirement that a minimum percentage of the fleet be equipped with pre-wetting units.

**How does pre-wetting work?**
The science of breaking the bond between ice and the pavement surface require three elements to be present - heat, moisture and time. Salt in its solid form cannot melt the ice. At the right pavement temperatures ($0^0$C to $-10^0$C), salt will dissolve in the surrounding snow readily, turning it into a brine solution with a freezing point lower than water. Aided by the heat from the air and pavement and with time, this brine will penetrate the snow layer and causes the bottom layer of ice to melt enough so that tire contacts or plow action will completely break the ice bond (see diagram). By spraying a de-icing liquid onto the sand/salt mixture (pre-wetting) prior to releasing the mixture onto the road surface, it accomplishes two things. Firstly, this simple procedure accelerates the brine formation by providing needed moisture (reduces the time it needs to melt the salt). Secondly, this pre-wetted material will "stick" to the road surface better than dry sand/salt pellets, and thus, reduces the loss of material into the ditches.




Based on many years of experience by other agencies, it was determined that different chemicals used in the pre-wetting liquid will have varied effects. The key property of the chemical is its "eutectic temperature" or the lowest temperature at which the chemical can still effectively melt ice. Once the eutectic temperature is reached, the chemical begins to crystallize and is no longer effective.




The three primary pre-wetting chemicals used by the department are calcium chloride, magnesium chloride and sodium chloride (common salt). Calcium chloride has the lowest eutectic temperature ($-51^0$C), magnesium chloride in the middle ($-33^0$C) and sodium chloride being least effective at cold temperatures ($-21^0$C). However, both magnesium and calcium chlorides are hygroscopic – they can attract moisture directly from the air; therefore, these chemicals must be used under the right atmospheric conditions to prevent re-freezing of the road surface.

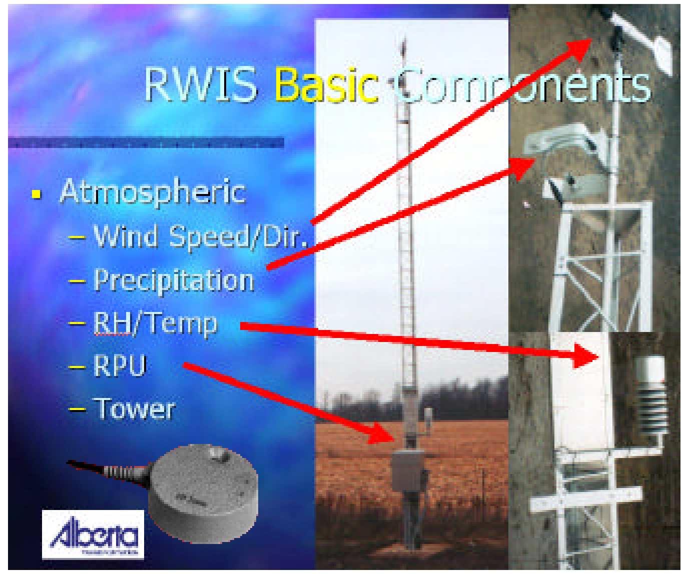
# ROAD WEATHER INFORMATION SYSTEM (RWIS)

**Allan Lo**

In the *"Pre-Wetting"* article, you have learned how important it is for the maintenance staff to acquire accurate and real-time atmospheric and pavement data in order to carry out the appropriate road treatment. It becomes even more critical during times when freeze-thaw cycles may occur throughout the day. Existing sources for atmospheric conditions come from Environment Canada's public and privately distributed weather reports and the pavement temperatures are obtained through the use of a portable infrared thermometer. We recognize the limitations of these tools because the accuracy of the atmospheric data depends on how close the environmental station may be to the actual highway sites and the thermometer can only be used when the maintenance staff drives to the site. These shortcomings are some of the reasons why we are considering the deployment of a network of Road Weather Information Systems (RWIS) for the province.

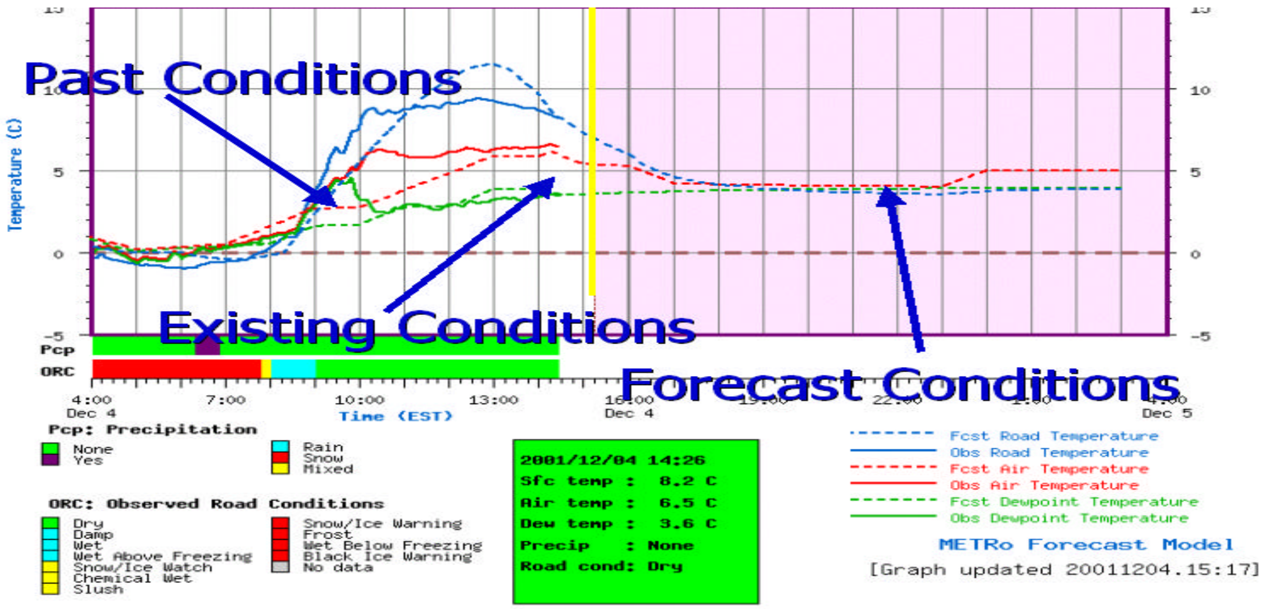
The concept behind RWIS is not new. Atmospheric and pavement sensors have seen limited winter maintenance use in the U.S. since 1947. Interest and funding for RWIS development and deployment accelerated after 1987 when RWIS technologies became one of the focused areas of the US Strategic Highway Research Program (SHRP). Major airports were also some of the pioneer users of RWIS technology because of their strict requirement for bare runways during adverse winter conditions. The City of Calgary had installed seven RWIS stations on their city roads since the mid 1980's, and four of these stations are now Alberta Transportation's responsibility because they are located along the Deerfoot Trail.

RWIS stations typically include an integrated suite of atmospheric sensors needed to detect key meteorological elements such as the air temperature, relative humidity, wind speed and direction, and precipitation (see photo). However, the most important feature to the road maintainers is the pavement sensors (sometimes called pucks) closely followed by the subsurface sensors.




Pavement sensors are able to detect pavement temperature, surface condition and amount of deicing chemical present as an indicator of pavement freeze point. The subsurface sensor is able to determine the temperature of the ground at a depth of about 450 mm (for prediction of frost). The latest type of pavement sensors is of the active variety - it has the capability to freeze liquids right on the sensor, allowing the instrument to determine the actual surface freezing point more precisely. Where necessary, additional sensors such as visibility sensors, traffic counters or web-based cameras may also be added to the suite. Information from these sensors is sent to a roadside remote processing unit (RPU) which is linked to a central server via land or wireless communications.

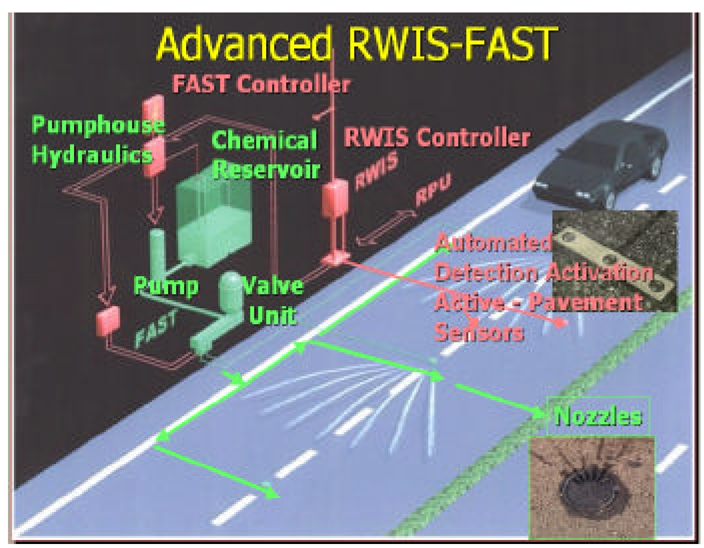
From the central repository, the RWIS data is then quality-checked, before it is fed along with a localized atmospheric forecast into a heat balance computer model (taking into account cloud covers and radiation heat loss) to generate a pavement forecast for the next 12 to 24 hours. Currently, Environment Canada performs both the weather and pavement forecasts for Calgary and Alberta Transportation. See a sample air and pavement temperature plot below.




Armed with up-to-date and accurate road and weather information, the maintenance staff can make better decisions on what type of chemicals and abrasives to use at what locations and in what concentrations, and to decide if pre-wetting is appropriate. Furthermore, RWIS will allow maintainers to go from pre-wetting to performing anti-icing techniques - laying down chemicals prior to the freezing event. This proactive just-in-time treatment will give ice less chance of forming and also as an added environment-friendly bonus, will reduce the amount of the "toxic" chemical needed ("To Salt or Not to Salt", May 2002 TSB Newsletter).

Aside from the benefit to the road maintainers, another ancillary benefit of RWIS is to feed the information into an intelligent warning system for highway travellers, which is why the technology is part of the Hwy 2 corridor ITS Study ("Hwy. 2 Intelligent Transportation System Project Update", October 2002 TSB Newsletter). Coupled with Internet and webcam technologies, it is possible to provide pre-trip planning information to the travellers through various media formats and to provide en route information via changeable message signs.

The next generation of Advanced RWIS will likely include another component called FAST or Fixed Automated Spray Technology. FAST is essentially an irrigation system designed to store anti-icing liquid and is programmed to release it onto the road surface based on RWIS triggers (very similar to a fire alarm triggering the sprinkler system in a building). See the schematic below. At a typical cost in excess of $500,000, a FAST system is generally reserved for high-trafficked problem locations that may develop slippery surface conditions faster than the maintainers can react to in time.



# BOW RIVER BRIDGE LONG SPAN PRECAST CONCRETE GIRDERS

**Abdul Waheed**

The recently completed 236 m long twin structures, crossing the Bow River south of Calgary, form an integral part of the Deerfoot Trail extension connecting to Hwy 2 (North/South Trade Corridor). The bridge is on a slight horizontal curve, however the girders are on a chord with the field cast curbs matching the roadway alignment. Because of the river setting in an urban environment, aesthetically pleasing piers were selected. The two-layer asphalt surface and waterproof membrane provided the wearing surface. The bridge construction began September 2001 and was completed in August 2002 at a cost of under $10 million.

The originally tendered design called for precast pre-tensioned segments of 48 m long for the end spans and 54 m for the center spans, with a 12 m long post tensioned hammer head (cantilever) section integral with the piers. The distances between the piers were set at 53.0 - 65.0 - 65.0 - 53.0 m. The girder superstructures composed of steel plates and precast concrete. The deck slabs were designed for both positive and negative live load moments.

Subsequent to the tender call, the girder fabricator, Conforce Structures, submitted an alternative value engineering proposal to eliminate the pier cantilevers and have the precast segments span from support to support using NU girders without any needs for splices. After extensive reviews, the proposal was accepted as equivalent to the original design. To our knowledge, girders of this length and depth have not been manufactured in plants, shipped and erected in Canada.

The centre span precast concrete bridge girders were the longest at 64.25 m long and weighed as much as 120 tonnes each. The 2800 mm deep girders had four 76 mm diameter post tensioning ducts and a web thickness of 175 mm. The girders were pre-tensioned to carry their dead weights, the shipping and erection loads as well as designed to carry live loads based on 81.5 tonnes trucks. Post tensioning was done in two stages. The first stage was to stress one tendon to create continuity for the deck's dead load; then, the remaining three tendons were post tensioned after the deck was cast, giving the structure continuous support for live loads.

The NU girder as originally developed by the University of Nebraska and Nebraska Department of Roads (DOR) had depths only up to 2400 mm. Based on the experience Alberta Transportation and Conforce Structures had gained from the production of the 57.5 m NU girders for the Taber bridge (first NU girder bridge built in Canada), there was a consensus that even longer and deeper girders could be produced.

High Performance Concrete (HPC) was used for the composite girder fabrication because of its fast-setting properties and high early and final strengths. The combination of pre-tensioning and post tensioning required concrete release strengths of 35 MPa and 28-days strengths of 65 MPa. Post tensioning of the entire bridge after casting the deck provides pre-compression, thus eliminating transverse cracking.

Special lifting devices in conjunction with a top flange bracing system was used during handling, shipping and erection of the girders to reduce the risk of top flange buckling. With the installation of the first girder, stability was initially provided through diagonal braces to the tops of pier supports; subsequent girders were braced diagonally to the previously installed girders. The NU girders exhibited better stability compared to other girder sections because of the wider bottom flange.

The NU girder system saved the department about 10% off the original cost estimate, which translated to approximately $1M. This project has been submitted to the Portland Cement Association in the US for the 2002 PCA Concrete Bridge Awards competition as recognition of its innovation and cost-savings.

# WILDLIFE-VEHICLE COLLISION COUNTERMEASURES

**Allan Lo**

Last November's gruesome reporting of a headless bighorn sheep found along Highway 16 near Jasper may have raised public awareness of an important issue – that wildlife/vehicle collisions occur much too frequently along our roads. In fact, almost one-third to one-half of all collisions on Alberta's rural roads invariably involves an animal (although no exact count can be established, nearly all these animals can be considered to be wild, a key element when designing countermeasures). Except for when large animals such as moose, bears and caribou are involved, many of these collisions do not cause severe injuries to people (in the year 2001, there were five fatal and 313 injury collisions out of 10,468 wildlife-vehicle crashes on rural roads). Nevertheless, the property damage and trauma tolls caused by these collisions cannot be taken lightly.

What can we do from a road authority's perspective to minimize these crashes? We do monitor the frequency of animal collisions along the provincial highway system and the information is taken into consideration during major construction or rehabilitation work. In some cases, the local maintenance contractors, the police or the wildlife officers may bring to our attention local trouble spots with a high number of animal road kills.

Let us examine some of the past and current countermeasures road agencies have deployed to mitigate this problem. One can visualize this problem as being two-pronged – one approach is to alert the drivers and the other is to deter wildlife from getting onto the road in the first place. They need not be used exclusive of each other; it is desirable within economic restraints to utilize both types jointly.

## Warning the Driver

The typical road warning signs you see are the animal warning signs. Unfortunately, these static signs cannot inform the drivers when and where an animal will appear. For some highways where larger animals like the caribou or elk may frequently be seen, we have installed non-standard oversized caribou silhouette signs with an illuminated red eye. After the novelty period has worn off, the true residual effects of these signs on the drivers become debatable.

Another driver-related measure some jurisdictions have used is reduced speed zones. Parks Canada placed several reduced speed zones of 70 km/h along Hwy 16 approaching the town of Jasper based on the frequency of animal sightings and the resultant traffic congestion. According to their study, "the number of elk collisions per 100 elk was reduced from 7.8 collisions/100 elk to 2.8 collisions/100 elk, a 5% reduction in elk collisions." However, the authors of the study also indicated that reduced speeds did not have an impact on the bighorn sheep mortality rates, likely because the sheep did not get easily scared off by traffic. The Jasper experience is somewhat unique because the locale is well known for its wildlife habitat. As a general rule, reduced speed zones are not always appropriate for open rural highways.

Other measures the department has implemented include improving the sight lines from the drivers to the ditches by clearing more trees/brush from the right-of-ways, and initiating driver education campaigns and publicity advertisements. The impact of these measures has not been evaluated.

## Deterring the Wildlife

A popular wildlife countermeasure that has been in use around the world is the so-called wildlife reflectors (the most "famous brand" being Swareflex, which has been replaced by the newer Strieter-Lite model). Strictly a nighttime countermeasure, the wildlife reflectors (shaped like a prism) redirect the headlight beam of an oncoming vehicle into the ditch. The theory is that this "unnatural" light would freeze the animals in their tracks and stop the animals from leaving the ditch. Typical costs are not cheap – a two-lane highway installation may cost $5-8 thousand per km. Many tests have been conducted around the world with some attesting to the device's effectiveness and others yielding no improvements. (refer to the US Federal Highways Publication No. FHWA-PL-02-011). The department conducted trials in the mid-1980s but could not conclusively show the device resulted in crash reductions. Currently, there are two Alberta-based studies of interest. The Alberta Conservation Association and the Spruce Grove Fish and Game Association installed reflectors on a 1.3 km section of Hwy 16 near Spruce Grove; Parks Canada installed test sections totaling 4 km long along Hwy 16 near Jasper (not in the reduced speed zones). We are still waiting for some meaningful statistics to come out of these experiments.

Wildlife Reflector

A very unique wildlife-vehicle prevention program was initiated in the winter of 1992 that involved both Alberta Transportation and Alberta Environment. A special species of caribou was rapidly being decimated by vehicular collisions along a short section of Hwy 40 near Grand Cache. In response, Alberta Environment conducted an extensive investigation into the causes and one of the recommended remedies was the so-called "Caribou Cowboy/Cowgirl" program (as dubbed by the media). The report stated that the number one cause for the caribou kills was the habituation of the animals to licking road salt, typically right before the winter season during the months of October and November. Special patrollers were hired during these two months to chase and harass the animals away from the road. The program was very effective in cutting down the animal collisions (from 27 caribou kills in two years to about one per year).

Caribou licking salt on road

While the "Cowboy/Cowgirl" program is still carrying on, there is some new research leading to potential use of taste aversion techniques to stop ungulates from licking road salt. The research work is summarized in http://www.trans.gov.ab.ca/Content/doctype255/production/rr9701.pdf. Lithium chloride appears to be the best deterrent of all the ones tested. The Parks Canada staff is carrying out some limited trials mixing the chemical into the road salt. Yet another possible biological deterrent is to use non-palatable plants within the right-of-ways to reduce wildlife foraging in the ditches.

The ultimate and most expensive method of preventing wildlife from reaching the highways is to build animal fences and under or overpasses for the animals to cross the road. Parks Canada is a major player in constructing many of these animal crossings on their TransCanada Highway twinning project through the Banff National Parks. The department's Civil Projects Branch installs wildlife fencing and abutment underpasses where major roads cross reservoirs. These fences successfully move ungulates to safe crossing locations away from the reservoir where both driver and deer can see each other. In 1998 when Alberta Transportation added the new Three Sisters interchange on Hwy 1 near Canmore, we deployed several different types of countermeasures to mitigate the its impact on the animal migratory patterns. Animal fencing 2.5 m high was erected along the tree line, and rock impediment was placed at the ends of the fence, both acting to channel the animals. A non-palatable mix of vegetation was also used in the surrounding landscape; cattle guards were installed on the road overpass; one new concept added was an animal jump area to permit errand animals to leave the right-of-way. All these measures complemented the most expensive centerpiece – an animal underpass about 4 m high and 7 m wide. From the lessons learned with the Parks underpasses, we specifically built two bridge structures for the highway lanes to give this underpass a wide-open appearance. The monitoring of the underpass activities seems to have confirmed the success of the passageway. All these mitigation measures added 23% ($1.3M) to the interchange work cost (fencing alone cost $27,000 per km). Adding wildlife fencing is also one component of the planning and construction of the Anthony Henday Drive.

Three Sisters animal underpass

**New Technologies, New Hope?**

Infrared vision is not a new technology, but what is novel is adapting this tool as a driver's aid in a vehicle. The potential for this in-car technology is to give drivers an advance warning of objects on the roads including animals and pedestrians during darkness (up to 450 m in advance for the Raytheon's XVision and up to 150 m for other systems as compared to 50 m for typical low-beam headlights). These infrared options range in costs from $2-3,000 US. The newest entry is the Ford's NightEye, which is actually an inexpensive night-vision optical camera that may cost a fraction of the infrared systems in the $2-300 US range.

The Insurance Corporation of British Columbia has recently partnered with InTransTech Inc., an Edmonton based company, on a project to deploy high precision infrared cameras in the Kootenay National Park to detect wildlife presence on/near the highway over an one-km range. Using heat pattern recognition software developed by InTransTech, an on-site computer activates the flashing lights on the warning signs to alert drivers to slow down. Only a limited supply of these cameras exists in the world and they cost well over $150,000 US each. There is hope that a much less expensive type of camera system may work just as well. Results from the 2002/03 winter season should be available later in the year.

BC's infrared camera on mast

On the other side of the fence (so to speak), there is a proprietary system developed by International Road Dynamics (IRD) of Saskatchewan. "The IRD Wildlife Warning System alerts deer of oncoming vehicles before it's too late. An approaching vehicle triggers one of two sensors strategically placed at either end of a traditionally problematic deer crossing. Remote units on either side of the roadway receive a signal and activate warning devices that alert deer with high frequency sounds, light or other commercially proven devices" (as quoted from IRD's website). This is a new development and actual field experiences may be limited.

Thus far, research has shown there is no "magic bullet" when it comes to deterring wildlife-vehicle collisions. Ideally, we need a comprehensive database on all wildlife-vehicle collisions, including road-kills that go unreported: species, gender and age of the animals. Above all, we need solid scientifically based research (not marketing data) on the various deterrent devices or techniques to give a road agency the right tools to combat the problem.

## AGGREGATE PROSPECTING USING HIGH RESOLUTION AIRBORNE MAGNETICS (HRAM)

**Bruce Blue**

The Regional Aggregate Co-ordinators have the important responsibility of managing the department's gravel pits and locating new deposits. Current prospecting methods include reviewing airphotos, maps, surface investigations, and hiring consultants to perform site testing using backhoes or hammer drills. Aggregate deposits (sand and gravel) are non-renewable resources that are slowly being depleted over time, and finding new deposit sites becomes increasingly difficult. When a completely new and innovative method was offered, Alberta Transportation was eager to test its potential.

High Resolution Airborne Magnetics technology or HRAM has been field-proven in finding oil, gas and diamond pipes, and the vendor claimed that HRAM could be adapted to help find aggregates. Early in 2001, the vendor approached Alberta Transportation to participate in an aggregate prospecting project in East-Central Alberta. Since the department's aggregate strategy is to provide optional gravel sources for construction projects, this proposal fit with the annual program for gravel prospecting. The department signed on to explore 22 townships of land.

The idea behind the technology is to record and analyze the magnetic signals given off by the magnetic particles in the aggregate, up to a depth of 15m. Flying at 100m above ground, an instrumented plane captures and records the magnetic signals at a line spacing of 400m. In post-processing, the data is first filtered to remove unwanted signals such as those from pipelines, well sites and power lines. Figure 1 shows one of the filtered maps as was produced during the project. The next step requires inputting other relevant data such as surface geology, water well data, terrain modelling, and known gravel sources in order to hone in on the targets for potential gravel deposit explorations (See Figure 2). Red signifies high priority, orange for medium priority and yellow for low priority areas.

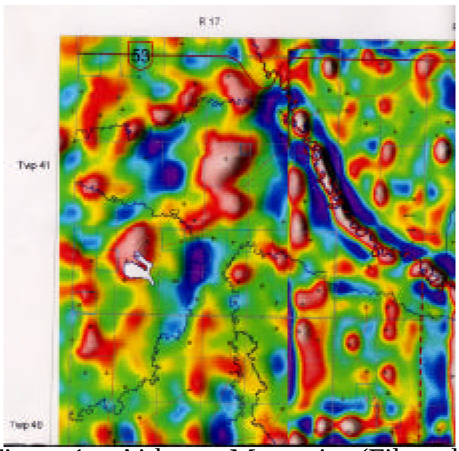


Figure 1 – Airborne Magnetics (Filtered)

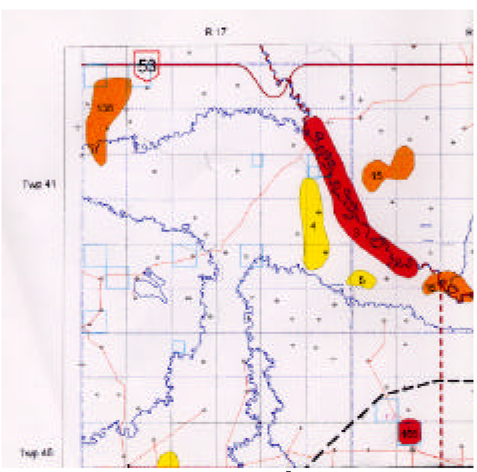


Figure 2 – Gravel Targets

In total, 83 potential gravel deposit sites were identified from the project. The high number of targets was a surprise because this area was thought to have become devoid of surface deposits. Upon cross referencing their data with department files it was discovered that twelve of the sites were previously known to the department: three targets were old depleted gravel pits that should have been discounted, two were stockpile sites, five sites were known to contain sand, and two others contained clay. This left 65 potential targets, many covering several ¼ sections, for further investigation. Of note, there were 13 other gravel sites used by the department between 1955 to 1997, that were not identified by the magnetic imaging to be potential targets. It was not known why some of the recent pits were missed as targets or known sources.

The department field tested a cross-section of targets on a random basis to determine if a full-blown testing program of all 65 sites was warranted. The fieldwork involved obtaining landowners' consent to enter their land and auger drill about four test-holes per quarter section to a depth of 15m. The gravel discovered would be sampled and analyzed. Of the 19-¼ sections investigated, the majority contained only sandy silty clay and layers of sand. In just one instance, pea gravel (less than 25mm in diameter) was encountered. According to the vendor, they suggested that the department should consider testing more of the high priority targets and that due to the large size of the targets, we needed more test coverage within the target zone. Unfortunately, based on the results from this trial, the HRAM technology did not appear accurate enough to warrant further investigation and evaluation. The department will continue to watch for new technical breakthroughs that will make the job of finding scarce aggregate resource easier and more efficiently.

**If you have an interesting technical article or know of an interesting project that you would like to share, we will be happy to hear about your ideas and newsletter-related comments.**

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