The Sustainability and Utilization of Water During Non-Destructive Digging

A Deep-Dive Analysis Into The Long-Term
Viability of Vacuum Excavation in North America

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Introduction

Vacuum excavation equipment is currently used extensively throughout North America, allowing for safe and efficient excavation processes, in and around delicate buried infrastructure systems. This equipment is manufactured to operate either primarily as a wet vacuum excavation system (hydro vac), or a dry vacuum excavation system (dry vac).

Both types of vacuum equipment are effective in a wide variety of tasks, however, dry vacuum equipment developed and manufactured in North America is very limited in power and can easily run into capacity problems, while wet vacuum equipment has logistical and environmental related issues that must be taken into consideration.

In contrast, throughout Europe, Dry Suction Excavation Equipment has been used successfully for over 30 years without running into any capacity or logistical obstacles. This equipment, primarily engineered and manufactured out of Germany, is predominantly accepted as the safest and most effective way to excavate when underground infrastructure is prevalent.

This paper will highlight relevant challenges currently experienced in the North American vacuum excavation industry, as well as provide insight into the advantages brought about by importing and integrating European technology into the North American marketplace.


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Ref. https://www.digdifferent.com/online_exclusives/2019/07/vacuum-excavator-usage-is-on-the-rise_sc_01b75

North American Vacuum Industry: Challenges

North American hydro vac equipment has gained wide acceptance throughout the utility industry as a safe and highly effective alternative to mechanical or hydraulic excavation. The process, which involves injecting large amounts of water into the soil to first liquefy it, is the principle differentiator from a dry vac system. Once the soil has been liquified it is now considered a "slurry" and is subsequently vacuumed into a holding tank. The water and soil mixture are disposed of at a designated transfer station or dumping facility. While effective, the application of this technology turns excavated material into waste, which if not properly disposed of, will have a negative impact on the environment, and so transporting and properly treating slurry increases overall costs to the end user.

Dry vacs manufactured in North America are typically smaller in size and less performant than a hydro vac, yet they have found to be operated effectively in niche markets that tend to have much smaller tasks or job scopes. Although they help to mitigate the afore-mentioned impacts of a hydro vac by keeping excavated materials dry and reusable, their productivity is reduced significantly in comparison to the hydro vac process due to design and engineering constraints. These factors often become evident when it is required to excavate larger amounts of material, as this type of dry vac system will slow productivity down over time, and as they are not engineered specifically to always be working with dry excavated material, they can quickly run into performance issues that will eventually lead to breakdown. This in turn has resulted in an overwhelming preference within the North American vacuum industry to excavate primarily with hydro vac technology.

Potable Water Usage

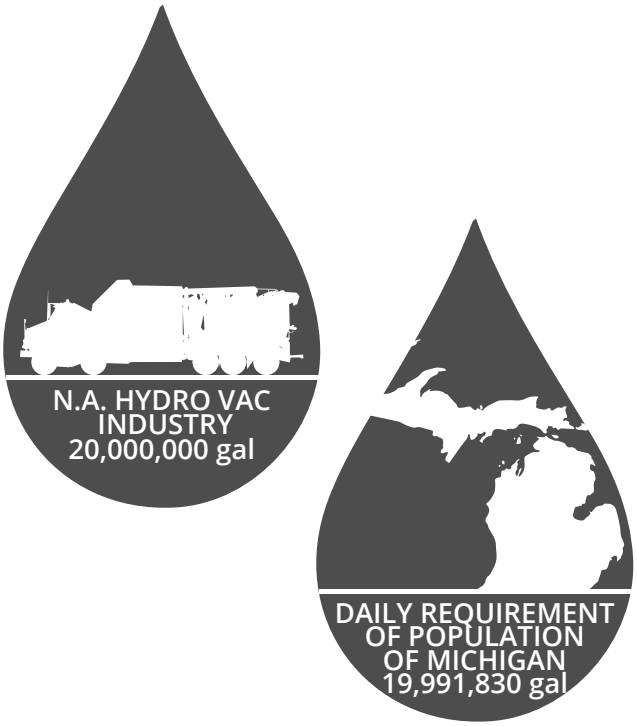
It has been estimated that every day the hydro vac industry in North America consumes an amount of clean water equivalent to the daily requirement of 10 million people - roughly the population of Michigan.

This water is a scarce resource, and, in many instances, also an expensive consumable added to the cost of the operation of the equipment. In some areas of North America water usage limitations are in place, and consequently using potable water for the purpose of excavation is viewed as both socially and environmentally irresponsible.

At any rate the levels of depletion currently observed by hydro vacs is not sustainable and must be reduced.

Hydrovac Slurry

Once the soil to be excavated has been liquefied into a slurry state it must be properly disposed of, tested, and treated - there are no exceptions. Slurry is an undesired but necessary byproduct of the hydro vac process which has high cost implications to both the end user and the environment. In the early days of hydro vac excavation, this slurry was often disposed of virtually anywhere, and at little to no direct cost. Currently, an increasing number of jurisdictions are enacting regulations that will require slurry disposal to take place at approved facilities.



Processing facilities are limited, and it is important to note that it is often an expensive and energy-intensive multi-step process when slurry is responsibly processed. In many instances, the slurry is mechanically screened, separating out larger rocks and debris; subsequent screening can be used to separate out smaller sand and gravel material that can be washed and then reused. When screening is complete, the slurry can be subjected to polymerization, flock tank, centrifuges and/or presses for additional processing to dewater and create a semi-solid state. The resulting material has no structure, can contain polymers, and often has a significant clay component, a material which tends to hold contaminants. This end 'product' therefore has limited to no commercial value and is generally transported to landfill for final disposal.

The cost to dispose of the slurry will vary geographically, however recent trends indicate that disposal costs are continuing to increase each year, and this has consequently added unforeseen expenditures to the excavation process. Ultimately, these additional costs are passed on to the utility, the municipality, or the project owner and create a negative impact on the environment.

Excess Soil Management & Contamination

Soil has been identified at a governmental level as an important resource, and the protection and conservation of soil is an important aspect of preserving the environment for present and future generations. As such, excess soil management, whether through mechanical excavation or vacuum technology, is being broadly considered and evaluated in various markets and jurisdictions and, as such, the liabilities associated to slurry are increasing.

Municipalities, as well as state/provincial governments, recognize that unlike clean, dry spoils created during mechanical excavation, once water is introduced into the excavation process, the resulting materials may need to be deemed contaminated until proven otherwise. As a result, the slurry now often requires environmental oversight and regulation. For example, operators in Ontario, a market that has embraced hydro vac technology for decades, are currently in the middle of evolving Ministry of Environment regulations and introducing On-Site and Excess Soil Management[1], which intends to:

- Recognize excess soil as a resource
- Set clear rules to increase reuse opportunities and reduce soil relocation costs
- Reduce clean fill soil going to landfills as a waste
- Reduce greenhouse gas emissions associated with the movement of soil
- Protect human health and the environment.

Under these amended regulations, excess soil would be designated as waste if leaving the project area unless it remains dry until its time of reuse or meets the new criteria being placed into O.Reg. 153/04 [2] and O. Reg. 347 [3]. Therefore, all hydro vac slurry will be considered waste and be subject to various environmental regulations with respect to transportation, disposal, and overall compliance documentation.

The province of Alberta, considered to be an early adopter of hydro vac technology, and headquarters to one the largest hydro vac supplied service organizations is taking an aggressive stance on hydro vac spoils.

The Environmental Services Association of Alberta (ESSA) clearly defines slurry as hydro vac waste:

generally comprised of about 60 per cent liquid and 40 per cent solid material – it is no longer soil and it is no longer water. As a result, the slurry must be treated at a unique waste facility that is capable of separating the solid from the liquid.[4]

Furthermore, regulations dictate that prior to the creation of hydro vac slurry, the generator (the owner of the land being hydro excavated and/or are the proponent for the hydro vac activity) should assess the site in order to determine the potential presence of contaminants that could become part of the excavated material and would then have to be managed, stored, or disposed of in accordance with current legislation. This is critical information to determine where the waste must be taken for treatment and/or disposal. Preliminary screening could include (but is not limited to): hydrocarbons, pesticides, E. coli, metals, polychlorinated biphenyl (PCBs), polycyclic aromatic hydrocarbons (PAHs), pH and salinity.

In addition to outlining the requirements associated with disposal of hydro vac waste at approved waste management facilities, and the various levels of site assessment to be conducted prior to excavation, the regulations further define the roles of generators, carriers, and receivers within the overall waste management process. For instance, those managing excavated soil must ensure that there is no discharge of contaminants into the natural environment and uphold the regulatory requirements of Alberta Environment and Parks as set out in Environmental Protection and Enhancement Act, the Waste Control Regulation (AR 192/96)[5] and the Activities Designation Regulation.

These increasingly regulated hydro vac operating jurisdictions are now leading many industry professionals to further consider issues surrounding soil ownership and responsibility, with the potential extension of liability to other stakeholders. It is reasonable to assume that other provinces and states will look to these jurisdictions for guidance and direction when developing their own specific operating and environmental legislation in response to their respective growing hydro vac industries.

Truck Weight Limitations

Commercial motor vehicles are federally regulated relative to their Gross Vehicle Weight Rating (GVWR), and vacuum equipment is governed by these same regulations. Hydro vacs are unique when it comes to scaling because at the start of the day they're transporting water, and although that water is displaced during its work on site, it is mixed into the excavated materials and essentially gets returned to the overall transportation weight.

Due to this unique factor, it's difficult to ascertain final transportation weights and hydro vacs are often scaled as "overweight", which leads to excess weight penalties, significant fines, as well as a negative impact on the CVOR or DOT rating of the commercial operator.

The US Department of Transportation documented over 8,000 overweight fines in 2017[7], and in the event of a motor vehicle incident involving an overweight load, the commercial operator and the officers of the company can become subject to severe legal penalties including imprisonment. The liabilities associated with operating vacuum trucks are directly related to transporting large volumes of water and thus the resulting slurry, and careful consideration needs to be given to how much water to load, and also how much material to excavate. So more frequently now, operators will leave a work site before the truck's full capacity is realized and projects will have to suffer scheduling inefficiencies and delays due to the untimely departure of the equipment being used.

Safety

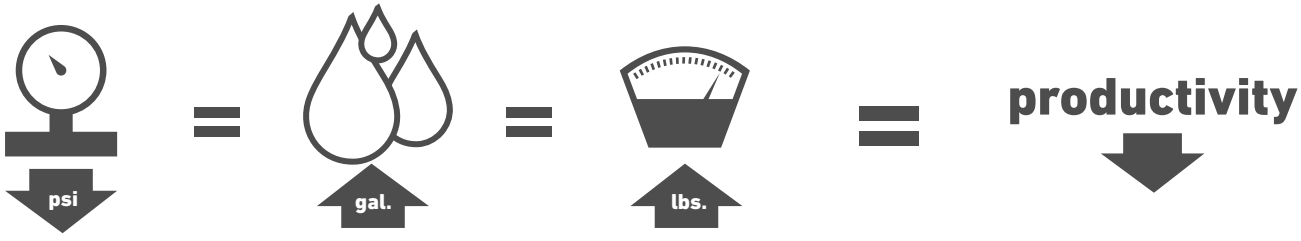
The use of high-pressure water around utilities has resulted in strict limitations on allowable pressures during the excavation process. Comprehensive testing completed by various regulators and industry experts have demonstrated that water pressures above 1500 PSI can, and will damage, some types of buried facilities[8].

While reduced water pressure is a best practice to put in place to mitigate the risk of damaging the buried infrastructure, excavation rates will be reduced as a result of the lower pressure. This in effect increases the cost per yard of soil excavated, due to more water being injected per cubic foot of soil vacuumed, as well as increasing overall excavation time.

When working around electrical utilities, water is never viewed as a good option and although operators have controls to put in place when working around live lines, the better control would be to remove the water altogether. Using a hydro vac to excavate around electrical utilities is, of course, more safe than mechanical excavation, but eliminating the water usage should be the goal.

Other safety concerns to consider under the construction regulations involve controls for slips and trips, access and egress in and out of excavated areas, as well as the overall housekeeping of the work site which are all effected by adding water and working in wet conditions.

To further, the use of water to excavate also often results in wet working environments for the technician and the utility tasked with entering the excavated site, which in turn leads to unsafe working conditions for both.



Environmental Impact

Utility construction activities have a direct impact on, and generate a significant footprint within, the environments and communities in which they serve. North American infrastructure systems require complex repair and replacement and they are critical to meeting the needs in delivery of the ever-increasing demands for utilities and services. If this work is not carried out regularly and these services are not delivered, there are social and economic costs, and if the work is not done efficiently there are negative consequences to the environment.

Every piece of construction equipment contributes to the overall carbon footprint of the construction industry, and vacuum equipment is no exception.

Vacuum excavation technology is an integral process in utility construction development, allowing for safe excavation during construction and rehabilitation projects. However, the equipment is also a contributor to greenhouse gas emissions, and due to the nature of the process employed by "wet" vacuum excavation, there are ramifications related to its carbon footprint.

When a hydro vac transports excavated slurry, it is transferring what was once clean potable water and clean reusable soil to a location where it can be processed and reused or dumped as waste. These facilities can generally be found outside of highly populated areas and therefore add a lot of travel time to each excavation job. Since most utility work is completed within the city environment, transportation will also be subject to the increased traffic congestion found in every major urban center, which once again adds to the impact on the carbon footprint of this equipment. Additional processing equipment involved to properly separate the slurry generate their fair share of emissions, and the requirement for other trucks to bring clean spoils back to site for the purpose of backfilling contribute to more traffic on the roads and on job sites. Finally, when factoring in a partially loaded hydro vac, due to provincial or state weight restrictions, the rate of transportation increases and the problem and impact on the environment is compounded.

Summary Assessment of North American Vacuum Equipment

Since dry vac equipment manufactured in North America is not engineered to efficiently produce results relative to the vacuum excavation industry, and due to their usage in only a minor capacity, an evaluation of this equipment is not relevant to the challenges faced regularly by the North American vacuum excavation industry and so is not included.
Therefore, the primary evaluation is that of a hydro vac and how North American markets have made adjustments to the increase in their utilization and presence in underground infrastructure development, maintenance, and repair.

What has been established over the three decades since their inception into the industry in North America, is that hydro vac equipment needs to be qualified and regulated as commercial equipment both on construction sites as well as on roadways. Furthermore, the materials produced by hydro vacs not only create a need for specialized waste disposal, they're also depleting potable water at an alarming rate.

This combination of generating significant amounts of waste in conjunction with excess usage of one of North America's most coveted resources, has been recognized as a liability on the government level, and as such, continues to be taxed and enforced in a manner that incrementally increases operational costs.

Solutions must be found to decrease the amount of waste produced by a hydro vac in order to reduce the carbon footprint generated by the logistics of utilizing this equipment. More importantly, discovering a process in which hydro vacs can be operated without having such a negative impact on potable water supplies would not only solve the majority of the obstacles faced by the vacuum excavation industry, they would also increase operational efficiencies and safety.


MTS
MTS

A Contrasting Perspective of the European Vac Excavation Industry

At around the same time that the hydro vac was being introduced to North America, non-destructive excavation methods in Europe were also being implemented. One of the key differences in underground infrastructure however, was age. Due to the brittle nature and population density in a lot of European countries, a solution was required that was able to maneuver in much smaller spaces and get non-destructive excavation work completed and potentially backfilled without having to leave the site. Another factor in the development of European vacuum excavation equipment was that water was not readily available, and disposal sites were not in range of most urban centers.

One of the solutions came out of MTS GmbH, a company that has been engineering and manufacturing dry vacuum suction excavation equipment in Germany for over 20 years. Today, dry vacs are recognized and known as the safest method of non-destructive excavation technology in over 30 different countries.

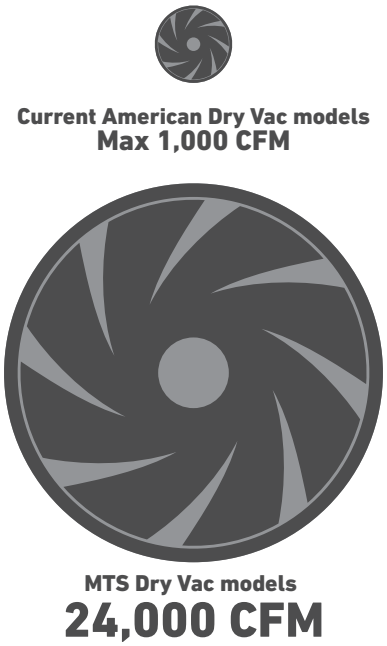
The following elements offer a different perspective on the challenges seen in the North American vacuum excavation industry, primarily because the same challenges don't exist in Europe due to this technology. Dry suction excavation results in savings, efficiencies, and a safer working environment relative to hydrovac excavation by simply removing the need for water. Purpose-built dry suction equipment creates the pressurized air needed to effectively loosen large amounts of soil, which once loosened can be safely vacuumed with a proportionately sized boom, enabling accelerated rates of soil excavation.

The Power of Air

By shifting the focus to air-powered ground disturbance tools to be used in conjunction with extremely high functioning air conveyance systems, dry vacs are able to perform very efficiently when excavating in the presence of underground infrastructure. As pressurized air loosens large amounts of soil without damaging any buried utilities, wires, or tree roots, the loose soil can then be vacuumed at accelerated rates of excavation.

This technology is far more advanced than the dry vacs seen in North America, as the difference in power is exponential. The majority of dry vac equipment manufactured in North America ranges in airflow strength, or cubic feet per minute (CFM), from 300 to 500 with some even boasting in 1,000 CFM fan strength. But dry vac systems from MTS are comprised of twin fan technology capable of outputting up to 24,000 CFM and come equipped with onboard compressors. Operators using European dry vacs can rely solely on the air supply provided by the dry vac and carry out the entire scope of an excavation project without needing to retool or refill any resources.

With the ability to excavate with air alone, there are no by-products created during excavation, and using air is easier on the operators while being unlimited in supply.



Excavating Dry Material

Dry vacs can be directly compared to mechanical or hydraulic excavators as the materials they extract remain unaltered and can be reused immediately for backfill or stored on site. There is no waste produced by dry suction excavation technology so this equipment can stay on the job until the work is complete and optimize project throughput.

Although hauling excavated materials remains an option for dry vacs, the logistics involved in testing and properly disposing of the spoils are eliminated because unaltered material that is dry can be stored or scheduled for reuse. Dry vacs also eliminate the need for specialized processing facilities, as dry materials can be stockpiled and, in the scenario involving contaminated materials, digging dry is essential for safe and productive excavation projects that are “inside the fence”.

Being able to dig dry and dump on site like most excavation equipment in general has many cost saving factors associated with it, so having dry suction technology for utility dense projects reduces costs per cubic yard excavated when compared to all other methods of non-destructive excavation.

Unlimited Resource

Dry vac equipment only requires air, which is plentiful and supplied in abundance in the case of advanced suction excavation technology engineered by MTS. Avoiding the need for potable water to operate not only protects a scarce resource, it eliminates the costs associated with using it.

There is a growing awareness and concern among various stakeholders (utility companies, governmental bodies and the general public), about the impact construction activities have on the environment, the community, and its resources. The ability to reuse excavated dry materials, or store for later use, is a direct response to address those concerns. By replacing the use of water with the use of air in non-destructive excavation processes, you negate the

need for fill materials as well as the logistics involved in delivering them.

The conservation of water is a catalyst for economic efficiencies during excavation projects, and those cost savings carry on through to the community where the work is taking place and ultimately the environment.

Load and Transport Reductions

Dry vac equipment can range in load capacity from 2 cubic yards, to 12 cubic yards, but unlike a hydro vac, the holding tank capacity is true - in that it does not have to account for materials above and beyond what it is tasked with excavating (ie. added water).
Specifications for transportation can then be accurately accounted for so that weight restrictions are adhered to when on the roads, and no special measures or manifests need to be put in place for the transfer of the excavated material.

A dry vac can therefore be likened to a dump truck in reference to transporting excavated materials, which means that no logistical adjustments need to be made, no disposal fees or special considerations need to be applied, and because the material is unaltered and dry, the option to simply move excavated materials from one location to another while remaining on site is an efficiency that can be realized.

This overall reduction in hauling loads keeps project costs down, it keeps trucks off the roads, and keeps excavated materials out of landfills.

Safety

The use of air prevents damage to underground utilities, wires, and even tree root systems, making them ideal for a wide variety of excavation tasks. The use of a dry vac also keeps excavated areas clean and dry allowing for unrestricted access and egress free of hazards. For work being done in open excavations, workers can enter the site immediately in conditions that are conducive to increasing project throughput.

Even in extreme cases like leaking natural gas lines, it was found that high flow rates of air can keep gas concentrations below the lower flammability limit as the combination of a variety of vacuumed materials in the air stream can provide a thermal mass sufficient to inhibit and even quench combustion[8].

There are many factors that lead the vacuum excavation industry to believe that dry vacs are the safest method of excavation working in and around buried infrastructure. One of the clearest indicators however, is that they have been used globally for several decades without incident.

Offering Environmentally Responsible Solutions

The construction industry in general creates a significant carbon footprint within the communities in which they serve and apart from eliminating the consumption of diesel, there's no direct counter action that can be established.

However, through research and development, engineering and design, it is possible to ensure that there are solutions provided for the environmental concerns that can be controlled, mitigated or even eliminated.

Through the advancements in technology in suction excavation, and with organizations like MTS continuously improving upon over 20 years of experience in the development and manufacturing of dry vac equipment, it is possible to save essential resources like water, reduce material waste, and apply environmental responsibility to the vacuum excavation industry in a cost-effective manner.

Summary Assessment of European Vacuum Equipment

The technology that gets engineered into the optimization of air flow in suction excavation products is why dry vacs are considered the most effective vacuum excavation equipment in the world. Incorporating the use of powerful, high velocity fans capable of generating up to 24,000 CFM, as opposed to positive displacement blowers that are common in North America, make it possible to dependably rely on the suction capabilities of dry vac equipment.

When used together with pneumatic tool options powered by compressors built into the same equipment, air conveyance is maximized and can be maintained for long periods of time without wear on the equipment and with little impact on the physical condition of the operator. Hours of operation are further increased by specifically designing all components and debris paths of this equipment to handle harsh, dry, abrasive materials and effectively preventing any premature erosion.

By streamlining each of these elements on the equipment and removing any dependencies on resources other than fuel, the rate of excavation is accelerated beyond any comparison.

Evaluation and Suggestions

When looking at the vacuum excavation industry as a whole and taking into consideration the factors that distinguish one piece of equipment from another, it's important to note what it costs to be efficient for each stakeholder involved in the development, maintenance and repair of underground infrastructure.

The primary cost originated at the utility owner, in discovering the liabilities and expenses incurred as a result of damaged infrastructure, and so, a non-destructive method of excavation became the driver for the vacuum excavation industry. Many iterations and innovations came about as a result of the demand, but only some were successful, and fewer still passed the test of time.

The hydro vac equipment that was established in North America was a quick and effective response to the needs that arose in the construction sector, and for many years has solidified itself as the equipment of choice for non-destructive excavation. In recent years however, more stringent regulations have targeted hydro vacs due the materials that get transported and disposed of, as well as the negative impact they have on potable water supplies. Unless hydro vacs can adapt to the ever-changing landscape of the construction sector and do so by decreasing the need for its namesake, digging wet will become a very costly endeavor for all parties involved.

The equipment that prevailed in Europe is what is now known as suction excavation technology, or dry vac equipment, and it has been efficiently performing for a long time without any adverse effects on the cities and communities in which it works. With ongoing improvement and engineering expertise coming out of organizations like MTS in Germany, this technology is continuously being developed and built purposefully with the intent of offering more than just damage prevention solutions for the construction sector.

The combination of advanced technology, operator input and application, high-speed excavation rates, and environmental consideration, make dry vac equipment the optimal solution for non-destructive excavations and it overcomes many of the challenges currently faced by the vacuum excavation industry and its stakeholders.

End Notes, References & Source Materials

1. On-Site and Excess Soil Management
   https://ero.ontario.ca/notice/013-5000

2. O.Reg. 153/04 Records of Site Condition – Part XV.1 of the Act
   https://www.ontario.ca/laws/regulation/040153

3. R.R.O. 1990, Reg. 347: GENERAL - WASTE MANAGEMENT
   https://www.ontario.ca/laws/regulation/900347

4. ESSA Hydrovac Waste
   https://open.alberta.ca/dat set/fbb7e433-f9d9-4656-a58a-fb951f84c7b7/re
   source/256a599f-85a5-483e-a67c-887632dc7a5c/download/hydrovacwaste-jan29-2018.pdf

5. Environmental Protection and Enhancement Act – Waste Control Regulation
   http://www.qp.alberta.ca/documents/Regs/1996_192.pdf

6. Oversize and Overweight Fines and Penalties By State
   https://oversize.io/regulations/oversize-overweight-fines-by-state

7. Vacuum Excavation Best Practice & Guideline – Suggested Updates
   https://www.gti.energy/wp-content/uploads/2019/04/09-Key
   holeSpring2019-GTI-Vac-Excavation-Best-Practice-Presentation.pdf

8. GTI research document - Vacuum Excavation of Potentially Flammable Gases
   https://sales.gastechnology.org/030128.html