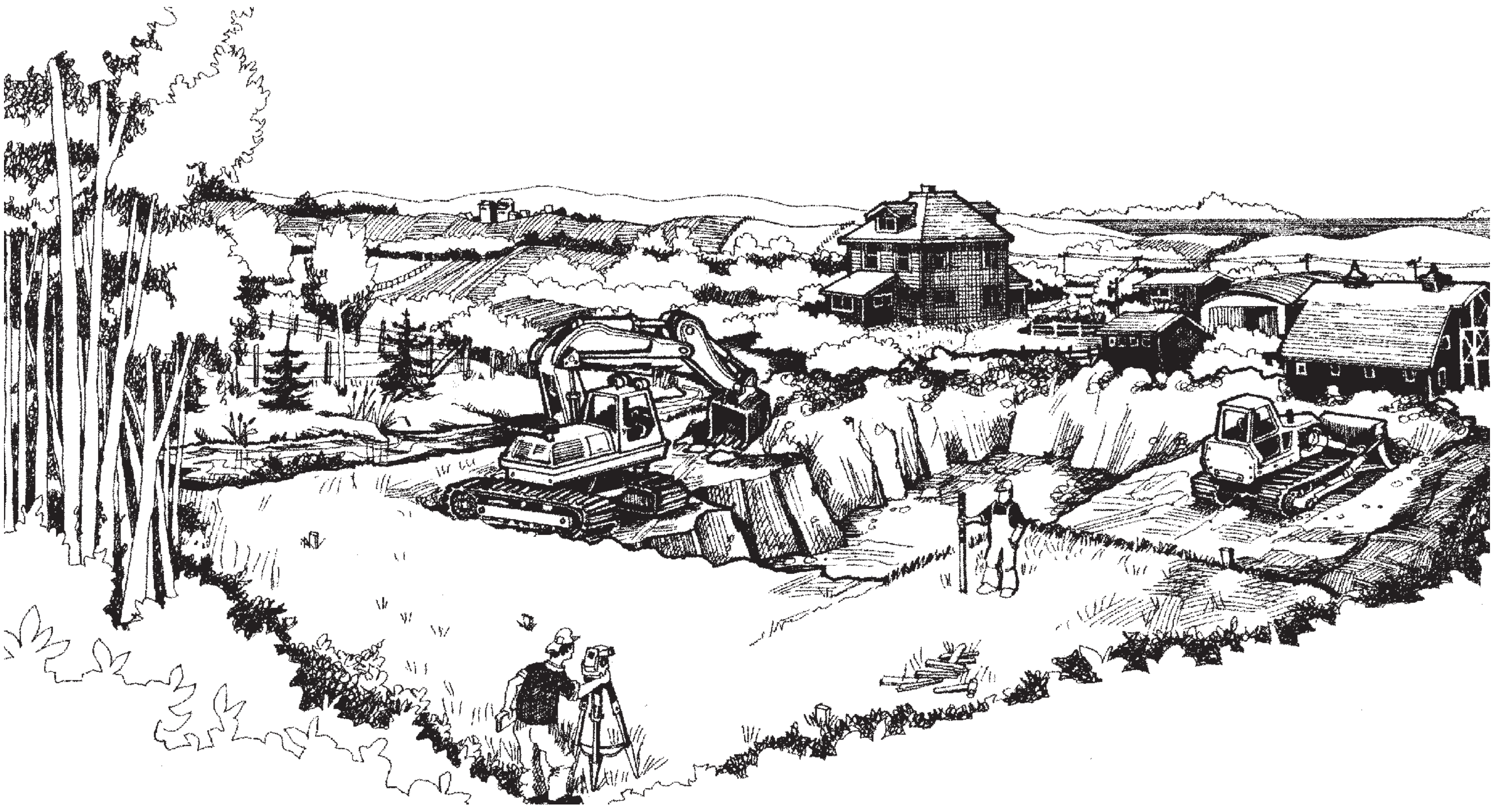
Design and Construction



Dugout Design

The construction and management of a dugout can have a large impact on water quality. Design options allow dugout owners to control inflow and permit only the highest quality water to be stored. Once runoff has been collected, good management can prevent water quality from deteriorating as illustrated in Figure 4-1 Dugout Design and Beneficial Management Practices.

Slopes

Historically, dugouts on the Prairies were constructed with 1.5:1 side-slopes and 4:1 end-slopes. The soil conditions and the construction equipment available largely dictated these specifications. Equipment capable of digging deeper excavations with steep end-slopes is now readily available. Steeper slopes reduce the growth of cattails and other aquatic plants that contribute organic matter and plant nutrients to the water. However, a dugout with four steep sides can be a safety hazard. It is recommended that dugouts be fenced to exclude livestock, and a flotation device should be available and used to protect children and adults from drowning.

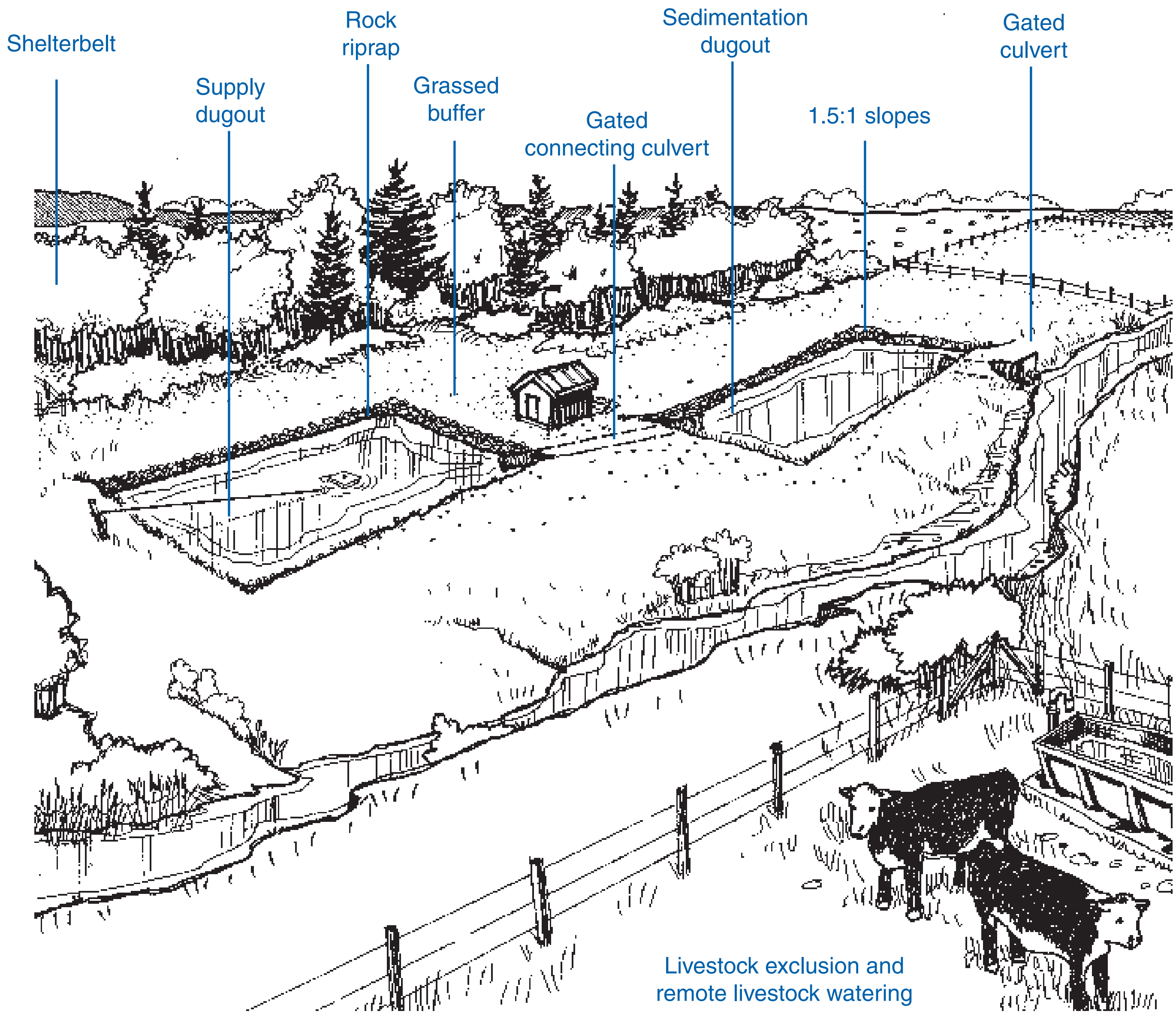
Erosion Control

Spoil piles are created during the construction of a dugout. If spoil piles are located at the edge of a dugout, they may erode or slump into the water. Spoil piles may also act as a windbreak and reduce wind mixing which incorporates oxygen into the water. It is recommended that the spoil piles around a dugout be leveled to maintain bank stability, and grassed to provide a filter that reduces the entry of soil and nutrients. Although the ideal width of a grassed buffer varies between sites, the recommended **minimum** is 33 feet (10 m).

Control erosion by leveling and grassing spoil piles and protecting dugout sides and end-slopes.

In windy areas of the Prairies, dugout life is increased when the dugout sides and end-slopes are protected to prevent soil erosion by wave action. This can be done with a combination of grass, rocks (often termed **riprap**), heavy plastic, or **geo-textile** materials. Riprap can also be effective at discouraging muskrats from moving in.

Figure 4-1 Dugout Design and Beneficial Management Practices



Inlet Structures

A dike and gated culvert inlet can be built to give the owner control over the inflow water. Poor quality water can be prevented from entering a dugout. The first flow of water from cultivated fields during snowmelt is typically high in dissolved nitrogen and phosphorus. Excluding this initial volume of water can improve water quality. Diverting flow away from the dugout is only practical where it is certain that there is more than enough runoff to fill the dugout. After the dugout has filled, the inlet should be blocked. This prevents sediment and nutrients carried by runoff from spring and summer rains from entering the dugout. If water is pumped into a dugout, prevent bank erosion from occurring at the discharge point.

Livestock Exclusion

Allowing animals to water directly from a dugout degrades water quality and drastically shortens the life of a dugout. Nutrients from manure stimulate plant growth and hoof action destroys dugout banks. It is recommended that all dugouts be fenced off and water supplied to livestock through remote watering systems. This protects the dugout, its water quality, and the livestock themselves. Many options are now available for supplying water to livestock on remote sites. Where a dugout is far from electricity, alternative power sources including windmills, solar panels, gravity systems, and animal powered devices, such as "nose pumps", are reliable and affordable options.

Design your dugout to exclude cattle; supply water to livestock through remote watering systems.

Sedimentation Dugouts

Much of the unwanted material that enters a dugout in runoff is suspended. If water is allowed to stand, much of the suspended soil and organic matter will sink to the bottom. In locations where the soil is highly erodible, and the landscape and costs permit, two dugouts can be constructed adjacent to one another. The first will act as a settling pond. High quality, surface water can then be either pumped into the supply dugout or allowed to flow in by gravity.

In a situation where an existing dugout is being replaced with a new one, it may be useful to retain the original as a sedimentation structure. The new dugout can often be positioned to fill with water that has been allowed to settle in the old dugout. This can be more beneficial and economical than cleaning out the original dugout.

Dugout Construction

Pre-Construction Testing

In many areas of the Prairies, sand, silt, and gravel layers occur close to the soil surface. Many of these layers can contain small amounts of groundwater that has seeped down from the surface. While many people installing new dugouts believe it is good to have water seeping into the dugout, these lenses of sand and silt can create many problems. They may provide a path for water to seep out of the dugout leading to depleted water supplies during periods of drought. In addition, highly mineralized groundwater seeping into the dugout can adversely affect the quality of trapped runoff water.

To ensure that sand lenses are avoided, dig at least five or six test holes or pits prior to excavating the dugout. Dig these holes around the outside and within the proposed dugout area to a depth of 4 to 5 feet (1.2 – 1.5 m) deeper than the proposed dugout bottom. They should not be located more than 100 feet (30 m) apart to minimize the possibility of missing intermittent sand layers that may occur. This testing will also identify other problems including shallow water tables and bedrock, as well as the most suitable construction equipment.

Large Scale Sealing Methods and Materials

If sand layers are generally in the area and no suitable site can be found, several additional test holes or pits may be required to determine the extent of the sand layers and help determine how to seal these areas. In some cases, it may be best to abandon the site and try to locate a dugout in more favourable soil conditions. In other cases, it may be simply a matter of over-excavating the areas of concern and backfilling with expanding clay to provide the proper seal.

For larger areas, the potential for seepage must be addressed at the time of construction. If it appears that seepage will be a problem, then most sealing methods will require flatter slopes of approximately 3:1 for the sealing treatment to be applied.

Clay Lining

If a source of good heavy clay is available, it may be feasible to haul and spread the clay into the problem areas and use packing equipment to pack the material into place to form an impermeable layer. The packing of the clay is normally carried out with specialized equipment known as "sheepsfoot" or "footed drum" packers, as shown in Figure 4-2 Footed Drum Packer, which are capable of exerting extreme pressures to compress the material into impervious layers. Care must be taken to compact the material in thin layers of not more than six inches (15 cm) thickness each time to ensure proper compaction is achieved. In dry soil conditions, water must be added to achieve proper compaction. Generally, six passes with a packer will achieve the proper mixing and compaction for a good seal. The thickness of the clay liner that will be required depends on the clay, but should be at least 1 1/2 to 3 feet (45 – 90 cm) thick.

Consult a professional soil or water specialist if large-scale sealing is required.

Figure 4-2 Footed Drum Packer

Bentonite

Bentonite is a highly expandable clay that is mixed with the soil and packed into place to seal the excavation. Once the dugout fills and the bentonite becomes wet, it expands and provides a very impervious seal.

Sodium Chloride

If the clay content of the soil is in excess of 20 per cent, a sodium-bearing compound such as sodium chloride can be incorporated into the soil to produce a seal. If this practice is followed, soil tests are required to determine the clay content and the amount of sodium compound required.

Plastic Liners

While plastic liners are available to prevent seepage, they are expensive and must be installed according to the manufacturer's instructions. Some plastic liners are ultraviolet light protected and have a 10-year guarantee. For plastic liners to last longer, they must be either thicker or covered with a sand layer. To place a sand layer on a plastic liner requires a low slope. Any tears in the liner can cause it to fail. In certain cases, air trapped under the liner can float it to the water surface. For high water table conditions, drains must be installed to lower the water table. This will prevent ground water pressure from below, lifting and floating the liner.

Gleization

In place of the traditional methods of sealing porous soils, a dugout can be sealed using a method called **gleization**. This involves covering the dugout bottom with 6 inches (15 cm) of chopped straw. The straw layer is then covered with 6 inches (15 cm) of clay and compacted into place. As the straw decomposes under low oxygen or anaerobic conditions, a rubbery blue-grey substance is produced that seals the pores between the soil particles. Since bacteria are breaking down the organic matter, the seal takes time to develop. Water will seep out while the seal is forming.

Perimeter Trench

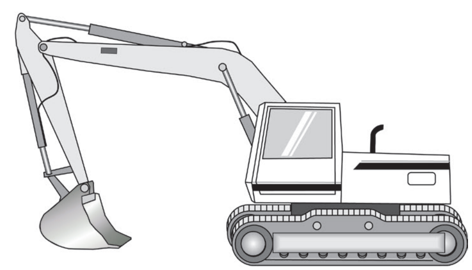
If the sand and gravel lenses are only located in the upper portion of the excavated area, a cut-off trench can be installed. The trench should be dug as deep as the bottom of the dugout and be extended around the total perimeter of the excavation. The trench is then filled and packed with good clay to form a perimeter seal. If the existing soil is generally high in clay content with only minor layers of sand and gravel, the material excavated from the trench can be mixed up and packed back into the trench. Since the lenses of sand and gravel are no longer continuous, the dugout will hold water. If good clay is not readily available, a cutoff curtain made of woven polyethylene fabric can be installed.

Excavating Equipment

Trackhoe

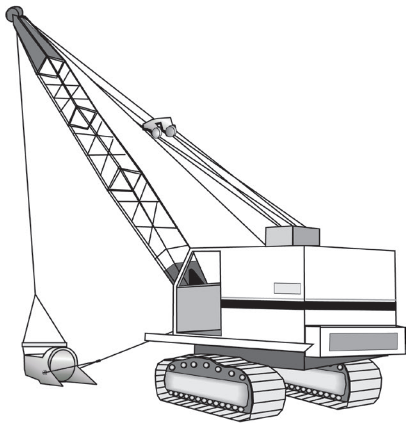
A tracked hydraulically operated excavator, commonly referred to as a trackhoe as shown in Figure 4-3 Trackhoe, is a large backhoe mounted on caterpillar-type tracks for maneuverability and flotation. Due to availability, ease of operation, versatility, and speed and ease of transport, the use of trackhoes for digging dugouts has increased dramatically. Since these machines are very fast, they can remove large quantities of earth in a very short time. Also, they complete all the work from the top edge of the dugout and do not need to crawl in and out of the excavation. Trackhoes are able to excavate the end slopes of the dugout to the same angle as the sides. They have a distinct advantage for excavating wet materials.

Figure 4-3 Trackhoe



The main disadvantage of this type of unit is the reach of the boom, and consequently the width of the dugout that can be conveniently built. Some of the newer units, with extended booms, are able to dig dugouts 60 to 70 feet (18 - 21 m) in width. Due to the shorter reach, the soil removed is piled very close to the edge of the dugout. This can lead to collapse of the banks due to the extra weight of earth. Because it is impractical to move and spread the excavated material with a trackhoe, the spoil pile presents a problem. For wider and deeper dugouts, the trackhoe can move the excavated material a second time. A better option is to use a dozer or a large loader to move the piles of excavated soil back away from the edge of the dugout. The fill can be used in low areas or to establish dikes to control the flow of water.

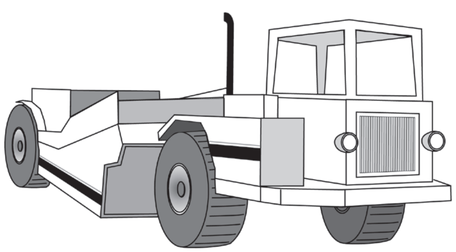
Figure 4-4 Dragline



Dragline

While the dragline shown in Figure 4-4 Dragline has been around for many years, its use in digging dugouts has declined in recent years due to the difficulty of transporting it. It is slower and less versatile than a trackhoe. Due to long reach and flotation, the dragline is ideally suited for installing dugouts in swampy or low-lying areas. Draglines can excavate dugouts up to 70 feet (21 meters) in width. In addition, because of the reach, spoil banks can be kept away from the edge of the dugout but, as with the trackhoe, it is impractical for the dragline to move and spread the excavated material to other areas.

Figure 4-5 Scraper or Buggy



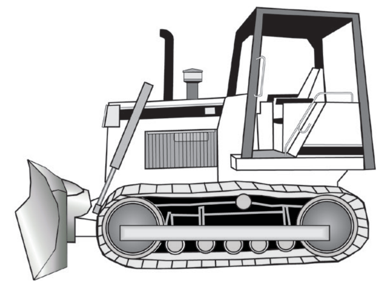
Scraper or Buggy

Motor scrapers or “buggies” as shown in Figure 4-5 Scraper or Buggy are large units that are used to remove, carry, and deposit the earth from the dugout excavation. Buggies are mounted on rubber tires and have the advantage of being able to move large amounts of earth very quickly. They can easily move the material to other areas for landscaping and diking purposes. As the hole becomes deeper, and the soil more compacted, this type of unit may encounter problems with traction and in some cases may require a cat with a ripper tooth to loosen the soil before excavation. Track-type scraper units are slow but have better traction and can work in more varied soil conditions. The main disadvantage of these units is the need for gently sloping end-slopes to allow entry and exit from the excavation. It is recommended that these flat slopes be steepened with a trackhoe.

Dozer

While a dozer as shown in Figure 4-6 Dozer can excavate a dugout alone, it is a slow process and will result in large spoil piles at both ends of the dugout. Wet soil conditions can cause delays and problems for a caterpillar. However, due to its traction, it can operate in a variety of soil types. As with other scraping equipment, dozers cannot construct steep slopes on all sides. Gently sloping end-slopes are required for entrance and exit from the excavation. The end-slopes should be steepened with a trackhoe.

Figure 4-6 Dozer



Selecting a Contractor

Experience

While digging a dugout may sound easy, how it is built will determine how long it lasts and how well it performs. For example, the slope of the sides will depend largely on soil type. The more silt or sand a soil contains, the flatter the slopes must be in order to prevent collapse. Similarly, sandy pockets or veins encountered during excavation may require sealing to prevent future leakage. An experienced contractor will recognize soil problems and inform the land-owner of possible solutions. Further technical assistance can be obtained from a soil or water specialist.

A dugout is more than just a hole in the ground.

References

A good contractor should be willing and able to provide a list of past clients. These references should be checked to see not only if the previous clients were satisfied with the work completed, but also how the dugout is operating and if any problems have arisen due to construction techniques utilized.

When you select a contractor to construct your dugout, look at such things as experience, references, equipment availability, time, and cost.

Equipment

The availability of equipment in the area will be an important factor in choosing a contractor. The equipment to be used should not only appear to be in good mechanical shape, but must also be appropriate for the site. The choice of the wrong equipment can lead to a very expensive dugout and one that may not be completed to your satisfaction.

Dugout Finishing

It is recommended that excavated material from the dugout be leveled, spread, and topsoil replaced. The final steps are to install any culvert inlets and trenches for water and airlines, replace the topsoil, and seed grass to a buffer area around the dugout and the in-flowing runoff channels.

Costs

Depending on construction conditions, certain equipment may be more expensive than others. To ensure the best price available, quotations should be obtained from several contractors whenever possible. Quotations are normally given in price per cubic yard or cubic metre of material removed. If the excavated soil is to be moved and spread to fill in low areas or form dikes, the cost should be kept separate from the dugout quote. As with any quote for work, it should always be in writing to eliminate any misunderstandings. Check to see if equipment transportation costs are included in the quoted price. Depending on the type and location of the equipment, transportation costs may be a major addition to the costs of excavation.

Time Factor

As with any type of contracted work, acceptable times for starting and finishing the job should be spelled out before any contracts are signed or work started. In many cases, availability of equipment will be the determining factor as most contractors are extremely busy in the fall of the year. Better prices may be possible if the work can be done in early summer, during the “off season”.

Construction Estimate

The first step is to get two or three dugout construction estimates. A sample construction estimate is provided in Figure 4-7 Construction Estimate to illustrate the important information that should be obtained from a contractor. All agreements for work should be in writing and signed by both parties. Written contracts help eliminate any misunderstandings as to specifications, timing, and costs. Remember that ultimately you are responsible for any approvals needed to build the dugout and its potential effect on natural waterbodies or downstream landowners. The example is based on the Joe Agricola farm dugout that was used in the Planning Module as an illustration of the use of the Dugout Sizing Worksheets. Carefully read through the completed example. A blank copy of the Dugout Construction Estimate is included in the pocket at the rear of the manual.

Figure 4-7 Construction Estimate

Dugout Construction Estimate Worksheet

This worksheet lists the items that a producer should discuss with a dugout construction contractor. A clear understanding between both parties is crucial so there are no misunderstandings or false expectations. Dugouts are far more than a deep wet hole in the ground.

Dugout Owner: *Joe Agricola* Dugout Contractor: *Dugouts R' Us*

Address: *Stettler, Alberta* Address: *Stettler, Alberta*

Dugout Location: Qtr *SW* Sec *6* Twnshp *39* Range *19* Meridian *W4*

Proposed Starting Date: *October 15, 2015* Proposed Completion Date: *October 22, 2015*

Proposed Dugout Use: Household *X* Livestock *X* Irrigation ______ Recreational (i.e., fish) ______ Other ______

Check Location of Underground Utilities: *Contact Alberta One-Call utility company to mark lines October 7, 2015*

Pre-construction testing; Test holes or test pits to identify potential problems including sand or gravel (i.e., seepage), high water tables, or shallow bedrock No. of test holes or pits *2* Depth of testing: *25 ft.*

Design Considerations for Dugout: Depth *21 ft* Width *100 ft* Length *330 ft* Volume *16,000 yd*^{3} Side slope *1.5:1* End slope *1.5:1*

Runoff or Flood Control: *A dike will be constructed around the dugout with a gated inlet to control runoff into the dugout.*

Seepage Control or High Water Table Conditions: *None expected – testholes will confirm.*

Types of Construction Equipment: Trackhoe *$175/hr* Dozer *$140/hr* Scraper ______ Dragline ______ Buggy ______ Other ______

Equipment Transportation Costs: *0.0*

Dugout Construction Costs:

(a) pre-construction testing	$ *175.00*	/hour	x	*2*	hours	= $ *350.00*
(b) stripping top soil	$ *140.00*	/hour	x	*2*	hours	= $ *280.00*
(c) excavation costs	$ *2.50*	yd^3	x	*16,000*	yd^3	= $ *40,000.00*
OR	$	/hour	x		hours	= $
(d) seepage control	$	/hour	x		hours	= $
(e) spread excavated material	$ *140.00*	/hour	x	*10*	hours	= $ *1400.00*
(f) dike and gated culvert inlet (i.e., flood control – optional)	$ *175.00*	/hour	x	*1*	hours	= $ *175.00*
(g) trenching water and air lines and install wet well	$ *175.00*	/hour	x	*2*	hours	= $ *350.00*
(h) topsoil replacement	$ *140.00*	/hour	x	*2*	hours	= $ *280.00*
(i) topsoil preparation and seed to grass						= $

Transportation and Construction Costs $ *42,835.00*

Tax $ *2,141.75*

Payment Schedule *Within 30 days of dugout completion* Total Cost $ *44,976.75*