AQUA DAM

Water - controlling water

Temporary Water Control

USER'S GUIDE

Authorized Distributor:

AQUA DAM AND DIVERSION LTD.
6970 - 10th Ave, S.E.
Salmon Arm, B.C. V1E 1X8
Canada

(250) 832 - 1332
Website: www.aquadam.com

LOW-IMPACT
ENVIRONMENTAL WATER DIVERSION,
CONTAINMENT, AND STORAGE STRUCTURES

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INTRODUCTION

Protection and objective management of water resources within the US and Canada have become significant public issues during the last two decades. The importance of conservation, water pollution, and the utilization of water resources is expected to increase as a result of increased demand, deteriorating water quality, pollution, protection of endangered species, and water shortages. Past practices by industry, public, and private sectors in the utilization of fluvial or wet land environments can no longer be tolerated. The days of building earthen levees within the ecosystem of a stream, river or lake are no longer acceptable to the general public.

AQUA DAM Water Structures offer a low-impact environmental alternative to past practices of building earthen barriers in fluvial systems by digging or trenching with large pieces of heavy equipment, which commonly caused long term damage to local streams, rivers, lakes, and wet lands. There is a growing realization of the importance of rational water management programs that protect water systems for future use, but also allows industry to continue in an economic manner. The Federal Department of Fisheries and Oceans,the British Columbia Ministry of Enviroment and the Ontario Ministry of Natural Resources have approved the use of AQUA DAM Water Structures, as a viable, environmentally acceptable means of diverting or containing water in water ways and wet lands.

The following is an overview of AQUA DAM Water Structures, including various applications, site and size requirements, equipment and manpower needs, installation techniques, safety, maintenance, and removal.

ABOUT THE COMPANY

AQUA DAM and Diversion Ltd. is an Authorized Distributor of Water Structures Unlimited, a California-based sole proprietorship created to offer a new concept for managing water diversions, water and silt containment, emergency flood control management, levee toppings, and water storage. Over five years of research, development and testing are involved in the present design of the AQUA DAM Water Structures described in this text. Several patents have been issued regarding AQUA DAM Water Structures, and a Canadian Patent is pending. Of course, development and testing of new designs and more efficient structures continues. Here in Canada, AQUA DAM and Diversion Ltd. offers water stuctures installation and consulting services regarding a wide variety of temporary containment, diversion, or storage needs, as well as the sale of AQUA DAM water structures for customer installation. Certainly, the most important features of AQUA DAM Water Structures are the ease, speed and cost efficiency with which they can be installed - generally, and in emergency situations.

PATENTS

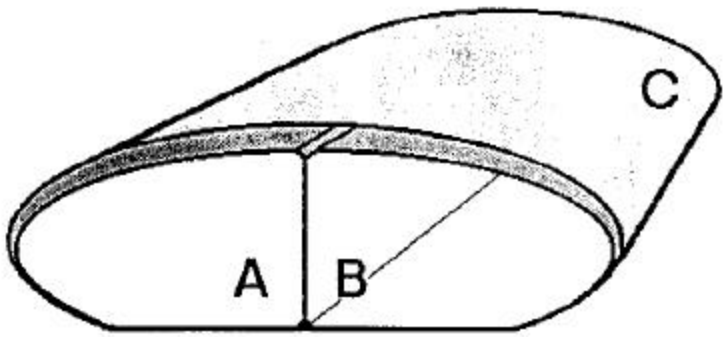
Water Structures Unlimited presently holds several US Patents on the design and utilization of multiple chambered AQUA DAM Water Structures, which use water as the inflation media, and the technique used in connecting or joining multiple AQUA DAM sections together:

Patent No.: US PATENT No. 5059065
Patent No.: US PATENT No. 5125767
Patent No.: Pending for Canada

CONCEPT

AQUA DAM Water Structures function like portable dams or barriers that are positioned wherever needed to contain or divert the movement of water. AQUA DAM Water Structures consist of two basic parts, 1.) an *'outer or master tube'* made of a woven plastic fiber, 2.) multiple *'inner tubes'* composed of 10 or 16 Mil. thick polyethylene. The *'outer tube'* and *'inner tube'* combine to form an AQUA DAM Water Structure as shown in **Figure 1**., a cut-away section illustrating the relationship between the *'inner and outer tubes'*.

TYPICAL AQUA DAM WATER STRUCTURE



- A and B are 10 or 16 Mil. polyethylene plastic *'inner tubes'*, which are inflated with water.
- C is the *'outer tube or master tube'* made of a polypropylene woven plastic fabric which confines the *'inner tubes'* and gives the AQUA DAM Water Structure its strength and durability along with the massive weight of the confined water..

Figure 1. A cross section of a typical AQUA DAM Water Structure illustrating the relationship between the two polyethylene *'inner tubes'* filled with water encased by a stronger but flexible *'outer tube'* made of a woven (GEO-TECH) plastic fabric.

Water is pumped into the *'inner tubes'* during the inflation process. The durable woven *'outer tube'* confines the inflated *'inner tubes'* and counter friction/hydraulic pressure between the *'inner tubes'* along with their inherent weight stabilizes the entire AQUA DAM Water Structure. Counter friction stabilizes the structure and keeps it from rolling when lateral water pressure is exerted against it. Given the inherent flexibility of polyethylene and the weight of the water structure when filled, AQUA DAM readily conforms to most sedimentary surfaces, river beds, or other fluvial terrains.

AQUA DAM Water Structures come in a variety of sizes, ranging from one to nine feet in height when inflated, and in standard lengths of 50, 100, and 200 feet. Customized lengths are available upon request. Two or more AQUA DAM Water Structures can be joined together to form structures of any workable length. Structures are joined together by a unique coupling collar method (patented by Water Structures Unlimited) which can create almost any length of water structure. The configuration of AQUA DAM Water Structures on the ground or in a fluvial environment is almost limitless. They can be used in a straight line, form an arc, or encircle a building. AQUA DAM Water Structures can also be connected at angles to each other, as may be required.

AQUA DAM Water Structures are commonly assembled at the factory and shipped, intact, ready to use at the job site. However, it is not unusual to assemble a water structure on site due to changes or specific needs of the job. A typical AQUA DAM Water Structure consists of the *'outer tube or master tube'* and at least two *'inner tubes'* wrapped around and rolled up on a wooden or metal core as shown in **Figure 2**. The core also plays an important part in the installation in some circumstances, as well as transportation of larger size AQUA DAM Water Structures around the work site.

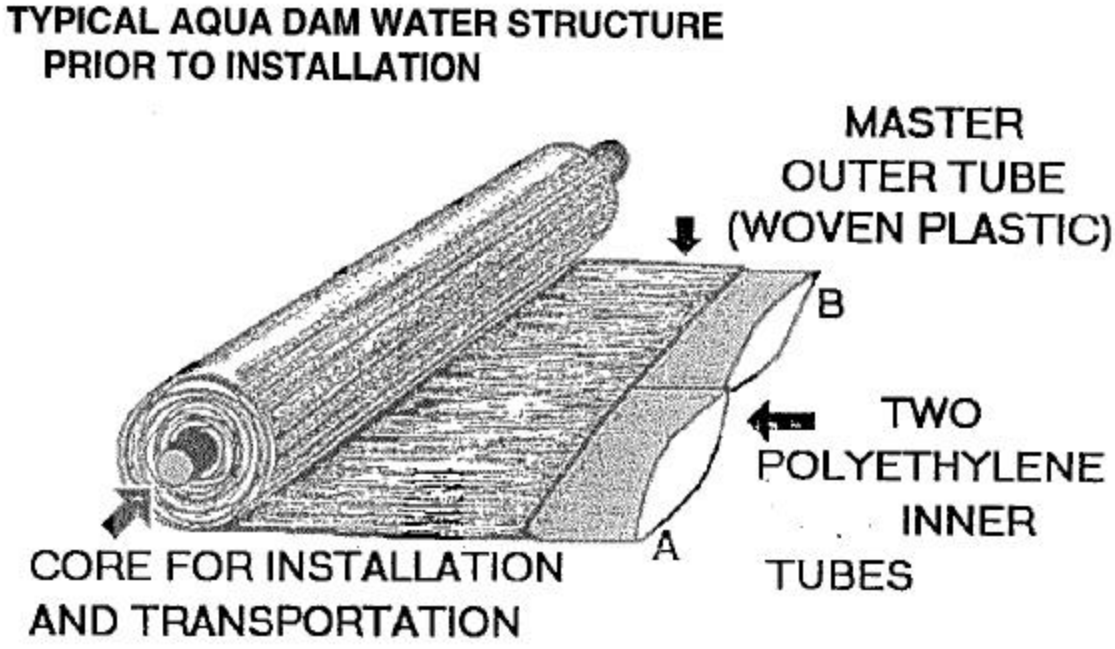


Figure 2. A typical factory assembled AQUA DAM Water Structure prior to installation, showing the *'inner and outer tubes'* rolled up around the core. One end of the assembled tubes is left open for filling purposes; the other end is sealed and/or may contain a coupling collar used in joining a second AQUA DAM Water Structure.

APPLICATIONS

AQUA DAM and Diversion Ltd. offers a wide range of applications for the use of AQUA DAM Water Structures as well as installation and consulting services. Listed below are some of the more beneficial uses or applications of AQUA DAM Water Structures:

- Water diversion during pipeline installation in rivers or standing water
- Water containment during repairs on bridges, sewage, and power plants
- Flood control in rural or urban areas - fast, effective installation times
- Erosion control through diversion or containment of flowing water

- Temporary reservoirs for water storage in arid areas
- Silt containment, sediment collection, or settling ponds
- Water storage for stock or wildlife in arid or drought plagued areas
- Water storage of spring run-off water
- Fire protection (water storage) in rural areas
- Levees, levee toppings
- Fish habitat restoration (containment)
- Agricultural uses
- Hazardous waste or oil spills (containment)
- Portable dams
- Temporary storage of hydrocarbons from spills
- Temporary foot bridge through environmentally sensitive areas
- Wet lands management

When used for flood control and augmenting levees, for example, AQUA DAM Water Structures are as effective as sandbags and sheet piling. Yet, they can be installed much faster and at a fraction of the cost of these more traditional methods of controlling flood water. Consider also the amount of water that can be stored in a standard nine foot AQUA DAM Water Structure with a width of 34 feet and a length of one hundred feet. Filled to its theoretical capacity it will hold about 150,000 gallons of water! AQUA DAM Water Structures are durable, long lasting, and with proper installation and removal from service can be stored and used again and again. Should an *'inner tube'* develop a leak, polyethylene replacement tubes are available.

AQUA DAM Water Structures are relatively easy to install, requiring only a couple of portable pumps, an available water supply, and depending on the size of the AQUA DAM Water Structure, a few labourers. Manpower requirements are discussed later under the heading of Installation.

SITE SELECTION AND SIZE CRITERIA

Site selection criteria determines the size and number of AQUA DAM Water Structure to be used. Six standard sizes are presently available.

AQUA DAM Water Structure selection is determined by the height of water to be contained and diverted, stream bed slope, water velocity, and maximum projected changes in water levels after inflation. **Table 1.** lists the basic sizes of AQUA DAM Water Structures currently available and recommended water depth usage, in both a de-watered and a non de-watered application.

ORDER #	INFLATED HEIGHT (INCHES)	INFLATED WIDTH (INCHES)	CONTROLLED DE-WATERED	WATER DEPTH NON & DE-WATERED
AD15	18	36	12	15
AD02	24	48	18	20
AD03	36	84	28	32
AD04	48	144	36	42
AD06	72	240	54	64
AD09	108	408	78	96

Table 1. Standard sizes of AQUA DAM Water Structures and recommended water depth usage.Lateral pressures from flowing water as in a river may require multiple AQUA DAM Water Structures installed parallel with each other. Depending on the amount of current the above water depths would be lowered proportionately.

Water Depth - The height of water to be contained by the AQUA DAM Water Structure is most important in selecting the proper water struction size. It is advisable to obtain **ACCURATE** measurements of water depths along the entire installation area.
You should also allow for anticipated increases to existing water depths after the AQUA DAM Water structure has been installed.
Estimating the height of water to be retained by a water structure is often underestimated by 25-50% resulting in inadequate barriers, increased costs, and potentially unsafe conditions.

Water Velocity - When using an AQUA DAM Water Structure to stem a water flow, some consideration must be given to the velocity of the water running around the end of the water structure during installation. When the water flow is being pinched off during installation, the water velocity will increase and, depending on the firmness of the stream/river bed that the water structure is being laid over, may cause some undercutting around the end of the structure as it is being installed. This would result in an increase in the height of the water to be retained and should be considered when determining the maximum water height. Current velocity will also play an important part in the installation of an AQUA DAM Water Structure. For example, during installation, a water structure has to be filled to a higher capacity to prevent it from rolling downstream.

Installation Site - AQUA DAM Water Structures can be installed on top of most types of soils or fluvial bottom materials, including flat lying bed rock, mud, sand, gravel, small rocks, and vegetation. Select a site that is smooth, flat, and void of wire, rebar, sharp objects, garbage, glass or dead vegetation containing tree branches, etc. The slope of the river bed should also be relatively flat or inclined in the direction of the up stream or contained water. The entire area should also be checked for holes or washed out areas which may cause problems during installation.

Climate/Spring Run Off - Spring run-off from winter snow-packs, local wet seasons, and thunderstorms affect water levels in rivers, lakes, and wet lands. Projects that have flexible construction dates should be correlated with favourable weather conditions and potentially high water levels.

Other Site Criteria - All of the above factors are important considerations once the site has been selected. The following are additional factors that may influence the site selection.

- Width of the river is important, since a location on a wide, shallow river is easier to control that a narrow deep river with rapids.

- An extremely rugged alpine river bed with large angular boulders, etc. within the stream bed is a difficult area to install structures, since a good, tight seal can only be accomplished by removal of such boulders by hand or heavy equipment

- Access to the area by road or trail is helpful in transporting the AQUA DAM Water Structure. However, water structures *are* extremely portable and can be moved down a river or lake by boat. Rolled-up AQUA DAM Water Structures will also float.

INSTALLATION

Installation procedures in this section cover AQUA DAM Water Structures installed in either standing or moving water. Both require the same procedures; however, flowing water does pose problems which require additional manpower, water pump capacity, and possibly assistance from heavy equipment if permitted. The size of the AQUA DAM Water Structures to be installed and the velocity/volume of flowing water dictates the equipment and manpower needs at the job site.

SMALL AQUA DAM WATER STRUCTURES (AD-15 -02-03):

Equipment List:

- Two portable water pumps (200+ gpm) or one split outlet pump (200+gpm);
- 2+ inch discharge and suction hoses per pump;
- Two or three wet suits (chest waders);
- One roll of duct tape per each installed AQUA DAM Water Structure;
- Two or three pocket knifes or one per labourer on the job and one pair scissors;
- 100 feet of 1/2 inch rope per installed structure;
- Two shovels;

Manpower:

- Three or four labourers are required to install smaller, water structures. The number of structures to be installed, time constraints, and access to the installation sites may dictate the need for additional help.

LARGE AQUA DAM WATER STRUCTURES (AD04-06-09)

Equipment List:

- Two or four high capacity water pumps (300 +gpm minimum), pumps of equal output.
- A 3 inch, minimum diameter, discharge and suction hose per pump;
- Two or three wet suits (chest waders);
- One roll of duct tape for each installed AQUA DAM Water Structure;
- Two or three pocket knives, one per labourer and one pair scissors;
- 250 feet of 1/2 inch rope per line for each 100 foot structure that is installed, (ie: a four rope set up on a structure would require 1000 feet of rope);
- Two shovels.

Manpower:

- Five to ten labourers are needed to install larger AQUA DAM Water Structures; The exact number of labourers is related to structure size, number of structures, terrain, water velocity, water depths, and time constraints. Standing water conditions require the fewest number of labourers (usually 1-5).
  The following chart better describes the manpower needs during a typical installation of a 4 to 9 foot AQUA DAM Water Structures in moving water.

RECOMMENDED MANPOWER REQUIREMENTS DURING INSTALLATION IN MOVING WATER

	WATER STRUCTURE SIZE	ROPE ASSISTED INSTALLATION	NUMBER LABOURERS IN WATER	NUMBER LABOURERS ON PUMPS	NUMBER LABOURERS ON ROPES
AD15-02-03		No	1-3	1	0
AD04	4 feet	Yes-3	2	1	3
AD06	6 feet	Yes-3-4	2-3	1	3-4
AD09	9 feet	Yes-4-6	2-3	1	4-6

Table 2. Manpower requirements based on a particular size of AQUA DAM Water Structure in moving water. The chart also provides the number of ropes commonly used with a specific structure size. Note that 4, 6, and 9 foot structures are commonly installed with the aid of ropes. Only in standing water would rope assisted installations not be used on larger size water structures. Strong water velocities or currents require more manpower to insure proper installation and to secure the safety of those in the water. The above list does not address personnel that might be operating heavy equipment at the site. An activities coordinator or supervisor who oversees the installation procedure is also recommended.

In most installations, very little site preparation work is required. The area should be checked for objects that might puncture the AQUA DAM Water Structure during installation. It is also important to have the right size and length AQUA DAM Water Structure at the correct location. It's a "lousy" feeling when you install a 9 foot AQUA DAM Water Structure and find out you are 25 feet short! Check your measurements and don't forget the portion of the structure that "laps" onto the river bank, shore, or berm (about 8-10 feet).

This Guide assumes that all Federal, Provincial, Municipal, or City permits have been obtained by appropriate personnel, project contractor or the persons in authority at the site and that all conditions or restrictions have been addressed and discussed with the personnel installing the structures, field supervisors, and prime contractor and company management. AQUA DAM Water Structures also recommends that the buyer (Prime Contractor, Company Supervisor, etc.) fully understands the above permits and has authority or knowledge of what can, or can not be done within the river bed or lake should the use of heavy equipment be needed.

INSTALLATION PROCEDURES

1. Transport the structure to the installation point. Unpack and remove any shrink wrap or rope that may be securing the AQUA DAM Water Structure, with scissors, carefully.. Be sure not to snag or puncture the polyethylene as this would result in leaks. If the structure is to be moved by heavy equipment, use straps secured around the structure then connect the straps to the heavy equipment for transportation.

2. If ropes are to be used in the installation process, they should be cut and placed under the structure at this time, before water is added, and secured to the hold back bar or stationary piece of machinery, see **Figure 4**. Without these lines or ropes the pressure of the water in the "*inner tubes*' would cause the structure to unroll before the proper inside head pressure is achieved. The number of ropes (lines) required by a particular sized structure is discussed in **Table 2** and **Figure 4**. The ropes are attached to the base of the hold back bar, then run under the structure, over the top, and back to the bar, where they are tied off in a manner that would alow the rope to be let out sparingly. The rope should be twice as long as the length of the structure when inflated, plus an extra 50 feet. One labourer should man each rope and each labourer should understand all signals that might be used during the unrolling and inflation sequence.

3. Position the assembled AQUA DAM Water Structure perpendicular to the proposed deployment path and at an elevation (berm, river bank, etc.) higher than the highest projected water mark on the installed structure. It may be necessary to build a berm at the starting point by hand or with heavy equipment. Insure that the dam is aimed exactly where you want it to go as it can be diffucult to correct the line during installation. Start with as much of the dam on top of the starting berm as practical. This will allow you to fill the dam to its maximum level without having water escape out the fill tubes. Place a heavy (1/2" - 3/4") rope under the beginning of the dam, at the waters edge, and also at the end of the dam (just prior to it being fully installed). After installation this rope can be used as a choke line to aid you in the removal of the dam. Let the rolled up AQUA DAM Water Structure roll down the berm into the water. The water structures will float, but don't let it float away!

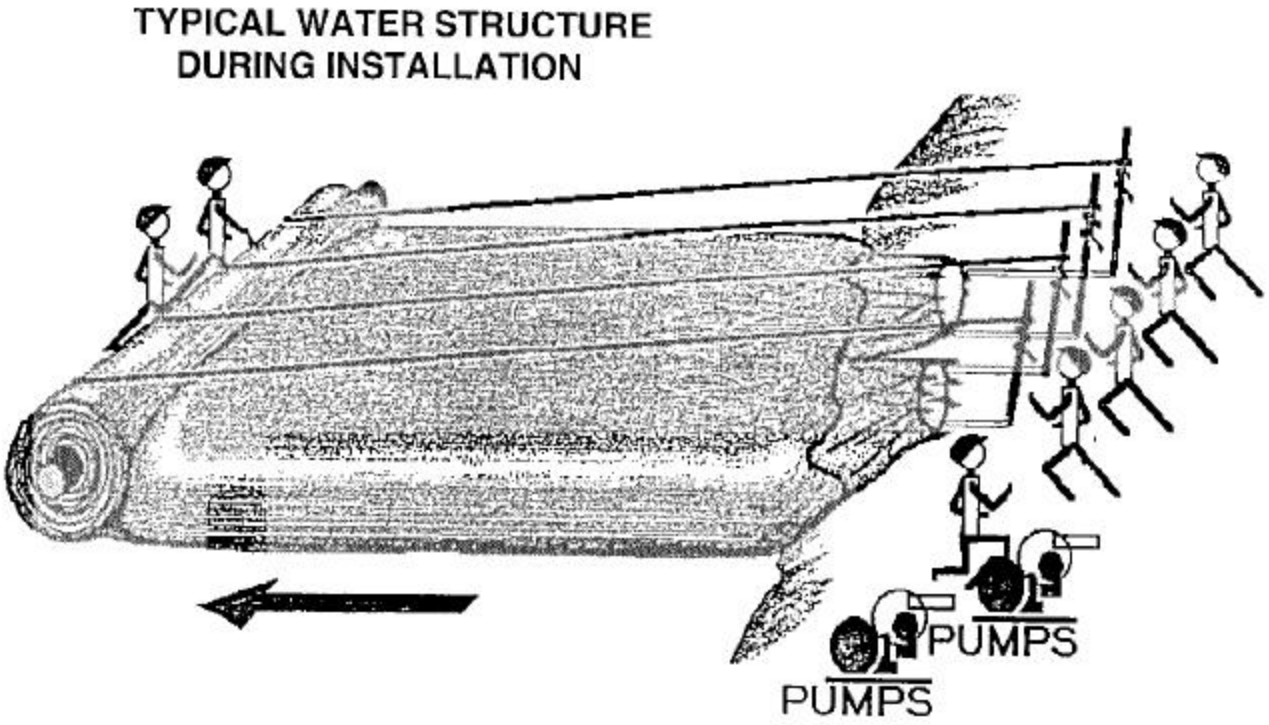


Figure 4. AQUA DAM Water Structure during installation showing the location of the ropes,hold back bar and the inflating structure.

4. After the fill hoses have been installed in to the *'inner tubes'*, a 'yard' of dirt dumped on the master tube between the two inner tubes at the very end of the structure on the berm, will help hold the structure during installation. Should the crew lose control of the structure during installation, this "yard" of dirt may keep it from taking off downstream, see **Figure 5**. Leave some slack in the *'inner tubes'* for tying off the ends after the AQUA DAM Water Structure has been filled.

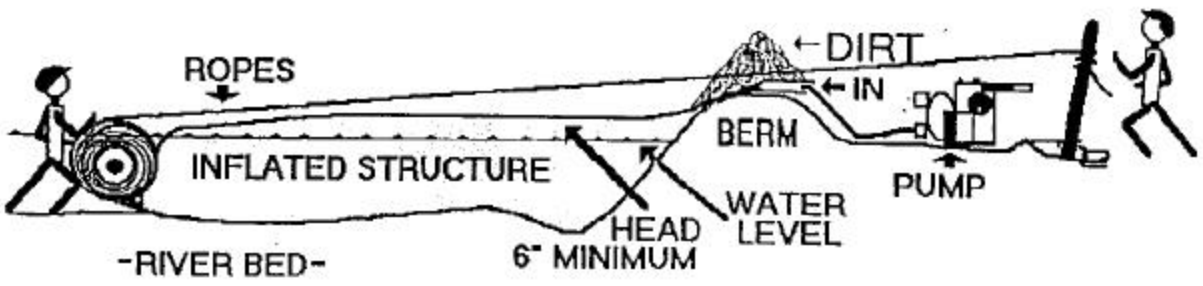


Figure 5. Cross section of a partly installed structure. Note location of the berm, pumps, ropes, and labourers.

5. Insert the discharge hoses from the water pump 6-8 feet into the polyethylene *'inner tubes'*, and gather up the loose polyethylene around the hoses and secure with duct tape, if necessary. If the end of the hose has sharp points or edges, wrap duct tape around them, since there will be a tendency for it to flop around when water is flowing through it. Be sure the intake (suction) hose is in deep water on the up stream side and not on the side being drained. Make sure the water pumps are full of gasoline and a spare five gallon gasoline can is stored nearby on land. It is very important that the *'inner tubes'* be filled rapidly and generally at the same pace (simultaneously). Be sure there are no kinks in the discharge lines from the pumps, as this will cut the pump capacities by 50-75%. The larger the water pump capacity, the faster the job will be completed. An AQUA DAM Water Structure 4+ feet high and 100 feet long should be installed in no more than 1-1.5 hours.

6. Once the ropes are manned, the pumps are primed and ready, and the AQUA DAM Water Structure is properly aimed in the right direction, the pumps can be turned on to begin the inflation process. The unrolled section should be unrolled at about six inches at a time to maintain a six-twelve inch head. Smaller structures can be unrolled more rapidly especially if the stream currents (water volumes) are small. Labourers should be aware that standing at the end of the unrolled section is dangerous should the ropes fail as the structure may unwrap rapidly, forcing a labourer under the structure. ALL LABOURERS SHOULD CARRY KNIVES to slit the structure open on both sides immediately to relieve water pressure on anyone pinned under the structure.

7. Only one person should give be giving signals to the "rope holders", perferably someone in water next to the unrolled portion of the structure, or the co-ordinator on top of the structure, as it is being unrolled and inflated. The co-ordintaor should also watch for structure movement or rolling in the unrolled structure due to an inadequte head, as well as movement in those structures already installed, if any.

8. Water should be entering both inner tubes at the same rate and the master tube should be rising out of the water equally on both sides. In flowing water, a head of at least 6-12 inches should be maintained in the structure at all times above the surrounding water. Head is described here as that portion of the AQUA DAM Water Structure that rises above the surrounding water during inflation. In stronger currents 12 inches of head should be maintained on the inflating structure, see Figure 5. Flowing water will have a tendency to push the structure down stream. The 6-12 inch of head of water within the structure is the positive weight that keeps the structure on the river bed - and from taking off down stream. However, the greater the head, the harder it is to restrict unrolling of the structure, so a happy medium must be worked out during the installation process.

9. 'ROLLING' of a structure during installation occurs when there is an insufficient head of water on the structure during or after installation. Water levels will rise rapidly during installation and should be monitored continuously by the crew in the water and the supervisor standing on the structure or in the water. Sometimes rolling is hard to detect, but the following may be indicators:

a. Visual lateral movement of the structure is evident.

b. The seams on the structure are straight for some distance but appear bent in the middle of the installed structure, bowing of the central part of section.

c. Water marks or muddy marks can be seen increasingly higher along the sides of the structure (usually crescent shaped marks).

d. The structure is no longer pointed in the direction originally taken.

e. Once installed and during the final inflation of the structure, an object placed down stream can be monitored to see if it is being encroached upon by the structure.

f. Rolling could occur in areas along a structure where, during installation the structure was turned or twisted. These are generally the weakest points along a fully inflated AQUA DAM Water Structure.

g. If rolling is beginning to take place or evidence of rolling can be seen along the structure, corrective action must be taken. A 1 or 2 inch change in water level could wipe out all of the installed structures! Keep a maximum amount of water in the 'inner tubes' and always fill your structures to their recommended height with heads of 12 inches or greater above adjoining water. Surrounding water heights may be higher than planned once installed. In this case the structure could be shored-up by using material from the river bed on the down stream side or river bank, see **Figure 7**. Remember that your Government Permit may not allow for any digging in the river. There should be an understanding of what can, or can not be done, to shore-up the structures with 2-3 feet of dirt/rock. Know your permits and be prepared.

h. Rolling should be monitored from the time the structure is being installed until it is removed from the job site, if it is of concern due to changing water levels.

i. Other solutions to 'rolling' are to install a smaller AQUA DAM Water Structure, directly down stream behind the rolling structure, or by increasing the amount of water in the structure. In standing water, the water that has been removed from behind the structure could be replaced/returned until a solution is reached, or water levels drop.

SHORING-UP CROSS SECTION

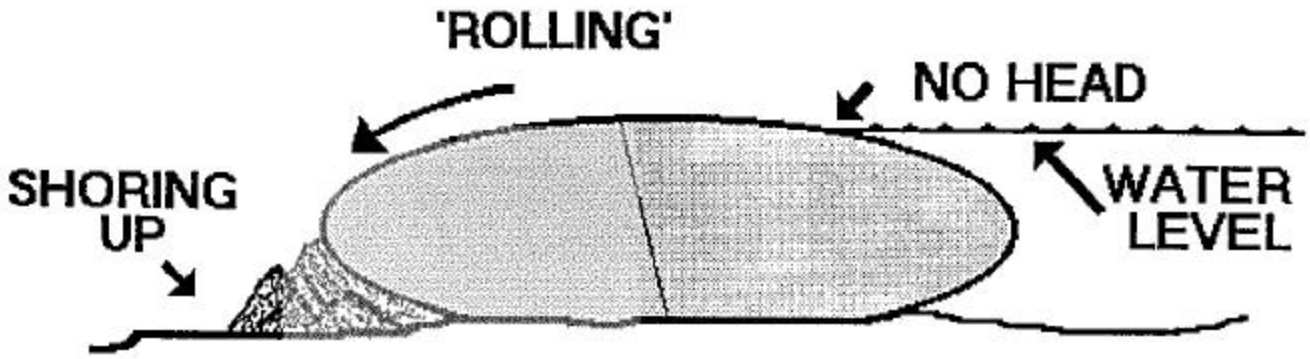


Figure 7. A cross section showing the placement of dirt/rock to shore up a water structure that shows signs of rolling. Other temporary solutions to rolling are the use of available heavy equipment as barriers or by installing a second structure behind the moving structure, immediately.

JOINING AQUA DAM WATER STRUCTURE SECTIONS:

Certain applications require that two or more AQUA DAM Water Structure sections be linked or coupled together to form a longer water structure. The following procedure illustrates how this is accomplished. The procedure assumes AQUA DAM Water Structures are joined in a straight line.

1. Before a second AQUA DAM Water Structure can be attached to an already installed water structure, the first structure must have an accessible coupling collar, see **Figure 8a**. The coupling collar should extend 6-10 feet from the end of the installed master tube. The other end of the collar is already tightly secured around the previously installed master tube, see **Figure 8a**.

2. Position the assembled new (second) AQUA DAM Water Structure directly behind and in-line with the filled section and unroll about six feet of the new section, see **Figure 8a**.

3. Gather up four or five feet at the end of one *'inner tube'*, lightly twist it or bunch it up, and wrap with duct tape, see **Figure 8b**. Repeat with the other *'inner tube'*. This will allow the *'inner tubes'* to be easily inserted and pulled through the slits on top of the master tube coupling collar.

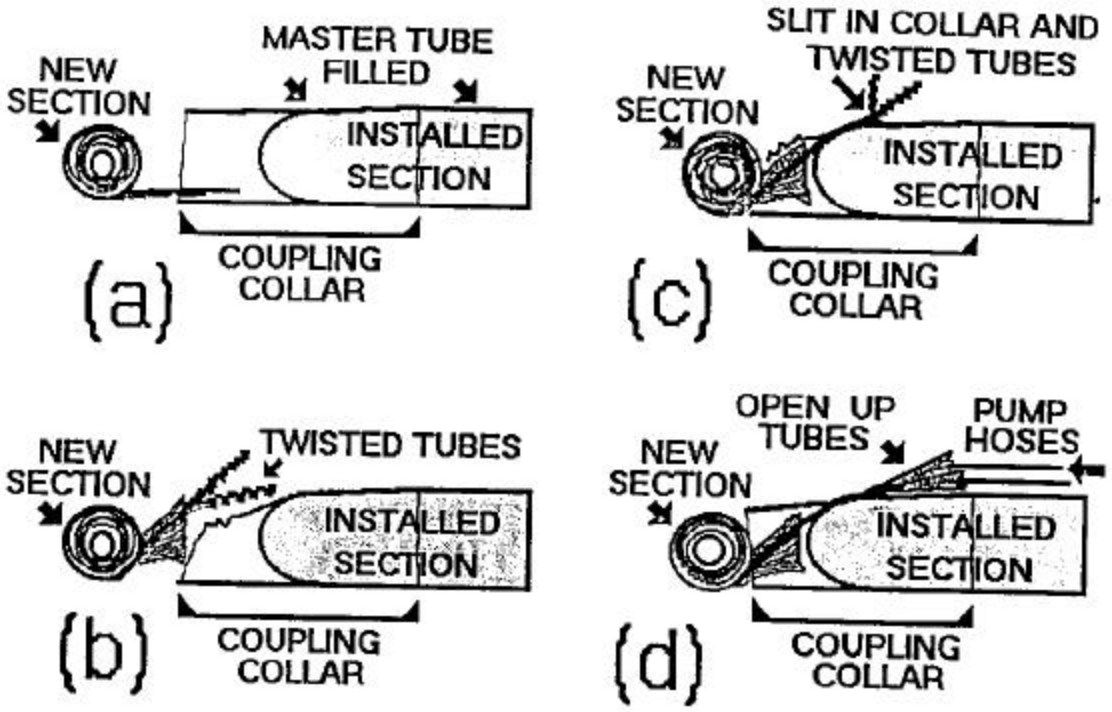


Figure 8 a, b, c, and d. Illustrations showing the different steps taken in the process of joining two AQUA DAM Water Structures together. No water has been pumped into the second (new) structure in any of these four illustrations.

4. Carefully cut two slits perpendicular to the length of the filled master tube. Each slit should be large enough to accommodate the wrapped *'inner tubes'*. The two slits should be positioned midway between the end of the coupling collar and the filled master tube up on the filled section. Again be careful not to cut the filled tubes of the first section, **see Figure 8c**. The slits should be about four feet apart on a 4-foot structure and six feet apart on a 6-foot structure.

5. Insert the wrapped right *'inner tube'* through the slit on the right side of the coupling collar and the the wrapped left *'inner tube'* through the slit on the left side of the coupling collar, see **Figure 8c**. This is done by working your way inside the coupling collar, pushing the *'inner tube'* toward the slit and having a second person reach through the slit and grab the tube and pull it through. The *'inner tube'* should be pulled up through the slit, about four feet for a 4-foot high AQUA DAM Water Structure and seven feet on a 10-foot high structure. Push and pull the *'outer tube'* fabric inside the coupling collar and around the *'inner tubes'* as best possible, especially on the bottom side. The new section should be totally enclosed by the coupling collar.

6. Remove the tape from around the twisted *'inner tubes'*, insert the discharge hoses deep into the unfilled *'inner tubes'* and secure with duct tape (see **Figure 8d).** Insert the pump hoses and secure them. Be sure there is extra master tube material and *'inner tube'* material inside the coupling collar to ensure a close fit with the end of the filled structure when filling of the new structure begins.

In strong currents it may be necessary to use ropes to restrain the unrolling of the second section in order to maintain a 6-12 inch head on the inflating structure. If ropes are needed splice them into the ropes used to install the first section and bring then up and over the second unrolled section. The ropes may have to be anchored to a piece of heavy equipment parked near the new take-off point, if the structures are no longer in a straight line or if you suspect the water currents will alter your direction of placement. The use of heavy equipment in the fluvial portion of a river must be in compliance with granted permits

7. At this point the new section is ready to be filled in the same manner as the first section. Follow all of the applicable instructions previously presented to install the first AQUA DAM Water Structure. **Figure 9** is a drawing of two AQUA DAM Water Structures, one filled and the other ready to be unrolled and filled

TWO AQUA DAM WATER STRUCTURES SPLICED OR JOINED TOGETHER

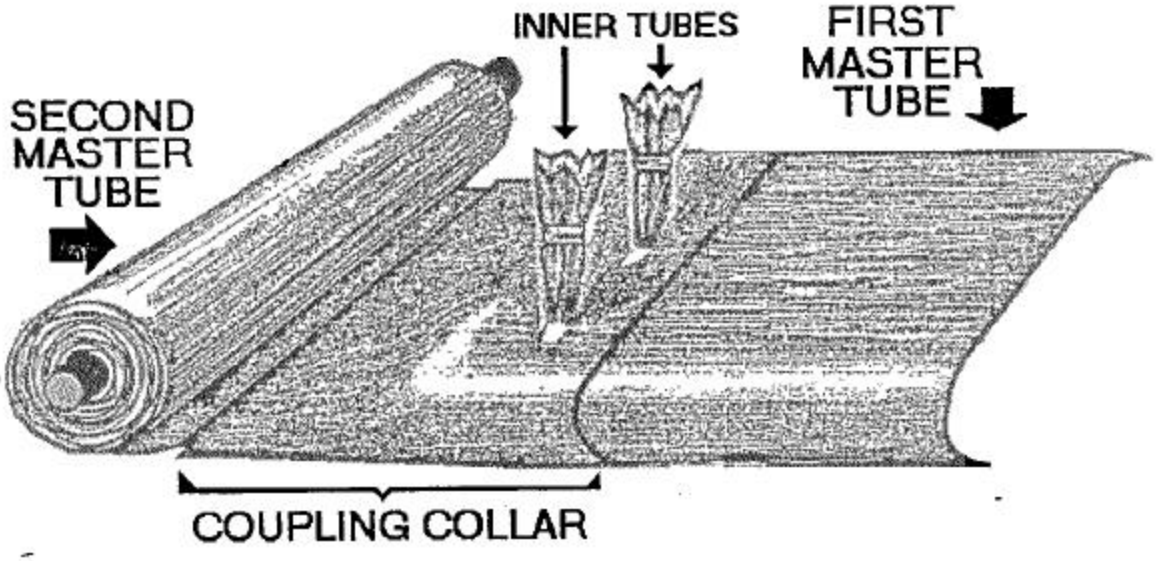


Figure 9. Two AQUA DAM Water Structures are shown joined together by a coupling collar, ready to be inflated. Note the two *'inner tubes'* sticking out and up from the middle portion of the coupling collar.

8. When the second section is filled, the water hoses can be removed from the *'inner tubes'*. The tubes are rewrapped with duct tape tightly and in such a manner that the tubes will stand upward by themselves. If possible, use duct tape to attach the two' upright *'inner tubes'* together, making them even more stable and preventing water from leaking out of the *'inner tubes'*. Remember the *'inner tubes'* are not on top of a berm, above water level, and lying flat on the ground as was the case for the first section, see **Figures 4 and 5**. Water could easily leak out of the *'inner tubes'*, if they were allowed to lay flat on the surface of the master tube. Keep the inlet tubes standing erect and tape accordingly.

9. Tie off the ends of the AQUA DAM Water Structures with rope where the sections are in contact with land. Check in and around the base of the installed sections for leaks that may be small at that time but can enlarge enough to under cut and wash the structures away. Fill or barricade the leaks with dirt, rocks, etc., it may be necessary to use a back hoe to move enough dirt to completely shut off these leaks. Material on the up stream side of the structure is most effective. Small flows of water are common near the bank where water currents were last cut off due to under cutting of the river bed during installation. These leaks should be plugged.

MAINTENANCE PROCEDURES

Installed AQUA DAM Water Structures are durable and should last a long time providing a regular maintenance program is implemented. The sections installed should be monitored regularly until any leaks can be located and rolling is not a concern. The first 12 hours is the most critical time.

There are four important observations that should be made on a regular basis. 1.) Leaks in the AQUA DAM Water Structures; 2.) Leaks under the AQUA DAM Water Structures; 3.) Infill tubes that have fallen over and are leaking; 4.) Rolling due to change in water levels.

Most leaks are of such a nature that they are resolved simply by pumping additional water into the structures on a regular basis. Identify which of the tubes is leaking, untie and unwrap the *'inner tube'* and insert the discharge hose from the water pump and fill it. Sometimes, a leak is large enough to require a patch. To repair such a leak, first identify and isolate the area of the leak. Then, using a sharp knife, cut a 'cross' through the master tube and pull the material apart to expose the leak. Then, using tape provided by AQUA DAM and Diversion Ltd., patch to the *'inner tube'*. Once the leak is repaired, cover the 'cross' cut in the master tube with the same repair tape. It should be noted that repairing leaks with patches is not recommended on AQUA DAM Water Structures greater than 4 feet in height. In most cases it is best to just add water on a regular basis

The woven GEO-TECH fabric that the master tube is made of is particularly resistant to penetration and can be walked on. The only time you might curtail foot traffic is during cold weather. Should ice form within the *'inner tubes'*, it may cut the polyethylene when it cracks or breaks due to foot traffic.

REMOVAL

In some cases, large dimensioned AQUA DAM Water Structures functioning as dams are used on a one time basis and are destroyed when removed. However, there are many applications where a water structure can be saved and reused at a later date. Specifically, wherever a water structure is installed in standing water or in an area where the water pressure can be equalized on both sides of the structure, it can usually be disassembled and saved for future use.

AQUA DAM Water Structures placed in a fluvial system can be difficult to save. Once the master tube is allowed to deflate the structure will roll down stream, twisting, etc. The quickest way to deflate the structure is to cut both sides of the section with knives, cutting through the master tube and the *'inner tube'* next to the fill tubes. Let the water drain from the structure, then pull it on shore. Using the coke line mentioned in **Section 3** of installation procedures.

Heavy equipment such as a back hoe can pull the structure from the stream or river while positioned at the river bank. The structure may be kinked and twisted beyond the point of saving once brought on shore. Try and save what you can.The outside master tube can generally always be saved,. If just the inside tubes are damaged, AQUA DAM and can supply new inside tubes that can be installed into the old master tube. Please call your nearest AQUA DAM Water Structure dealer for pricing of replacement tubes. Damaged *'inner tubes'* make good liners in and around urban landscaping projects to prevent weeds from growing. Also, the tubes are heavy enough (10 mil) to act as tarps over agricultural products or equipment.

The procedure to drain and disassemble a AQUA DAM Water Structure used in standing water for storage is described as follows:

1. Assuming that the structure is still lying in water, the structure should be first drained as best possible. Cut or untie the *'inner tubes'* at the far end of the structure and allow the structure to drain by slowly pulling the closed end of the structure up onto the bank.

2. After the AQUA DAM Water Structure has drained, secure the coupling collar by slipping the collar back over the master tube of the section until the collar is 1/2 way over the end of the master tube.

3. Flatten out the *'inner tubes'* and the master tube along flat ground, making sure that the *'inner tubes'* are not kinked or twisted in any way. If possible, use an air blower to facilitate the process.

4. Starting at the coupling collar end of the section, re-wrap the AQUA DAM Water Structure around the core used in the installation process, and secure it with rope for storage.

5. Detailed re-stuffing instructions are available from your AQUA DAM Water Structure distributor.

The polyethylene material used to make the *'inner tubes'* of AQUA DAM Water Structures contains a 1-year ultraviolet direct light stabilizer. The shelf life of a stored AQUA DAM Water Structure is indefinite.

SAFETY

Throughout this User's Guide, situations requiring installer care regarding conditions which could result in a safety hazard have been noted. A list of field safety hazards all labourers should be aware of is outlined below. These are worst case scenarios, but should be discussed regardless of their chances of occurring:

1. The floors of rivers and streams are rough and have holes in them. Labourers used in rivers, lakes, or streams should know how to swim. In cold water, insulated chest waders are recommended. Labourers can suffer hypothermia in 33-40 degree water, or lose mobility if exposed to cold water for 4-6 hours at a time.

2. Standing at the end of a 4-9 foot AQUA DAM Water Structure being installed or unrolled is dangerous should the restraining lines give way, or should the labourers in the water lose their footing due to strong currents around the end of the structure. In cold water, insulated chest waders are a must and knives are essential should the structure roll and trap anyone.

3. Rolling of the structure during or after installation can be dangerous to anyone walking on the structure or standing directly downstream. A structure that begins to roll is extremely unstable and dangerous. Tremendous volumes of water are being held back by the installed structures. Should one give way or breach, the wall of released water and resulting water currents can be strong enough to knock down the largest of men and carry him downstream. The greatest hazard when a structure rolls is that the structure wraps around a labourer's legs, knocking him down, and not allowing him to get back up. For this reason, all on-site laborers must carry knives, providing them with the ability to free either themselves or fellow laborers in the event of a problem. Should there be a concern for erratic changes in water levels which may affect installed structures, one "lookout" person should be posted at the site during working hours until construction is completed. This approach ensures that men working downstream, out of sight of the water structures, can be alerted of potential hazards should a structure roll or be breached.

4. Fording or crossing a river, stream or lake in winter months without proper clothing such as insulated chest waders or a life-vest is risky. Stepping into a hole, or a loss of footing, can result in a worker becoming soaked with freezing water, and ultimately suffering the effects of hypothermia.

5. If heavy equipment is being used on the site, normal safety procedures should be followed regarding their movement and use.

6. Labourers should use extreme caution when jumping from one structure to another, from a structure to a piece of heavy equipment, or from a piece of heavy equipment to a structure. One slip may result in an unexpected fall into very swift, deep water. Life-vests are recommended for all personnel working at the job site where water depths are greater than one foot, before or after installation of the AQUA DAM Water Structures.

For further information regarding this User's Guide, or the use or installation of AQUA DAM Water Structures, contact AQUA DAM and Diversion Ltd. or an Authorized AQUA DAM Distributor

Warranty and Liability

There shall be no liability on the part of the manufacturer (Water Structures Unlimited), or any distributor (including AQUA DAM and Diversion Ltd.), or any other seller for any loss or damage, direct or consequential arising from a buyer's use or inability to use these products, or inability to follow instructions for the use of, or installation of, said products as presented in this User's Guide. AQUA DAM and Diversion Ltd., via Water Structures Unlimited, warrants only the workmanship of the Water Structures purchased, and will repair or replace any manufacturing defects at no charge. This warranty does not apply to any Water Structure once it has been used, installed, or placed in service.

AQUA DAM

Water - controlling water

APPENDIX: AQUA DAM WATER STRUCTURE SPECIFICATIONS

ORDER #	DIMENSIONS (HxW)	VOLUME GALLONS*	SHIPPING WEIGHT
AD15	1.5' X 3.0'	2,500	0.9lb/foot
AD02	2.0' X 4.0'	5,000	1.35lb/foot
AD03	3.0' X 7.0'	12,000	2.2lb/foot
AD04	4.0' X 12.0'	25,000	3.6lb/foot
AD06**	6.0' X 20.0'	65,000	7.6lb/foot
AD09***	9.0' X 34.0'	150,000	17lb/foot

MATERIAL SPECIFICATIONS:

INNER TUBES: 10 Mil. polyethylene
** 15 Mil. polyethylene
*** 20 Mil. polyethylene elastomer

OUTER MASTER TUBE: High-Strength Woven Geo-Textile

*** Approximate Filled capacities in gallons per 100 foot section.**