

U.S. Department
of Agriculture

Forest Service

National Technology &
Development Program

2300—Recreation Management
0723 1807—SDTDC
May 2007



All-Terrain Trail-Trailer and Sprayer Modules



All-Terrain Trail-Trailer and Sprayer Modules



Cam Lockwood—Trails Unlimited, Enterprise Unit

U.S. Forest Service
San Dimas Technology & Development Center
San Dimas, CA 91773-3198

May 2007

Information contained in this document has been developed for the guidance of employees of the U.S. Department of Agriculture (USDA) Forest Service, its contractors, and cooperating Federal and State agencies. The USDA Forest Service assumes no responsibility for the interpretation or use of this information by other than its own employees. The use of trade, firm, or corporation names is for the information and convenience of the reader. Such use does not constitute an official evaluation, conclusion, recommendation, endorsement, or approval of any product or service to the exclusion of others that may be suitable.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

TABLE OF CONTENTS

All-Terrain Vehicle Specifications	1
ATV Towing and Power-Train Requirements	1
Electrical Requirements.....	2
Trailer Module.....	2
Trailer Equipment and Specifications	4
Fabrication	4
Sprayer Module	4
Fabrication	6
Field Testing	6
City of Pleasanton, CA, Spring 2004	6
Interpretive Trail, Alpaugh, CA, Spring 2005	7
Smithsonian Folklife Festival, Washington, DC, June-July 2005.....	8
Francis Marion Sumter NF, Enoree RD, SC, June-July 2005.....	8
Summary	9
Possible Use on Fires.....	9
Appendix A—Towing Capacity Charts	11
Appendix B—Fabrication Drawings.....	17



This publication discusses the all-terrain trail-trailer and sprayer modules. These modules were developed by Trails Unlimited—a Forest Service, U.S. Department of Agriculture, Enterprise Team, and San Dimas Technology and Development Center (SDTDC) partner—to meet the maintenance and construction requirements to keep up with the growing demand for trail-based recreation. Trails, often in remote areas, require a trailer with versatility, stability, and ability to travel over rough terrain. The sprayer module (sprayer) was designed to transport water and dust abatement or mulching products in a compact unit.

All-Terrain Vehicle Specifications

The trail-trailer carries the other modules and is towed with an all-terrain vehicle (ATV). Therefore, the ATV must be sized appropriately for the trailer load and its modules. Some ATV towing and power-train requirements are discussed below.

ATV Towing and Power-Train Requirements

All ATV operators must be certified according to the policies set by their agency. New certification includes towing. The ATV operator must be experienced and familiar with the ATV's handling characteristics when pulling a loaded trailer and has the ultimate responsibility of determining whether a load can be towed safely.

The trail manager and ATV operator must understand that not all ATVs are suitable for towing, and not all ATV models suitable for towing are appropriate for towing the trailer modules discussed in this publication. Direct questions about specific ATV model towing capability to the specific ATV-model manufacturer.

Check ATV-manufacturer specifications for the gross vehicle towing weight rating or GVTWR. The gross vehicle weight rating and power (engine displacement) must be appropriate for the towed load. This is especially critical when working on trails with steep grades or on sideslopes. See appendix A for a listing of GVTWRs for the most common ATVs.

The ATV should be a 4-wheel-drive utility model with an engine size no smaller than 500 cubic centimeters. Engine displacement of 650 to 700 cubic centimeters is preferred, depending on project needs and topography. Additional torque and low-end power are needed for steep slopes and rugged terrain. An aftermarket hitch system may be necessary for towing heavier loads.

The sprayer's dry weight (with an empty drum) is 300 pounds. It has a maximum load capacity of 2,500 pounds. Check ATV-manufacturer's recommendations for towing this size load.

The ATV must have an independent rear axle. Independent axles allow for a tighter turning radius on switchbacks and on remote and narrow trails. These axles also reduce the potential for front-end plowing in turns. Many ATV manufacturers offer a choice of models that include an independent rear axle.

Trailer brakes are necessary to control the trailer's additional weight and must be matched to a specific ATV. Due to the extra weight the ATV is towing, tires with a higher weight-carrying capacity may be necessary. At the same time, changing to a more aggressive tire will improve traction capabilities.

All-Terrain Trail-Trailer and Sprayer Modules

Electrical Requirements

The ATV should have a charging system that provides a minimum 40 watts-charging power and at least a 10-ampere-hour battery capable of charging the trailer's battery. An electrical retrofit for handlebar-mounted control wiring is necessary for the trailer-controls to be within easy reach of the ATV operator. The trailer-wiring harness uses a 7-pin heavy-duty truck/trailer plug (female) attached to the ATV. The male end is attached to the trailer.

Trailer Module

The modular trail-trailer (trailer) allows for more versatility without needing a trailer for each separate piece of equipment. Many attempts at using off-the-shelf trailers for trail work have proven unsatisfactory. This trailer system uses the same trailer-roll-off concept used by large waste-disposal trucks. During the test period, this trailer was extremely stable and smooth with no rollovers or near misses. The stability is attributed to, in large part, the walking-beam axle. See figure 1.



Figure 1– Trailer module with upper frame raised.

The trailer is essentially two trailer frames connected by a pivot and hydraulic cylinder. The bottom frame contains a walking-beam axle with brakes, hydraulic power pack, battery, and trailer tongue. See figures 2 through 5.



Figure 2– Hydraulic power pack and battery without housing.



Figure 3–Upper frame, raised, with hydraulic power pack and ram, and battery housing, note winch frame at the top of the photograph.

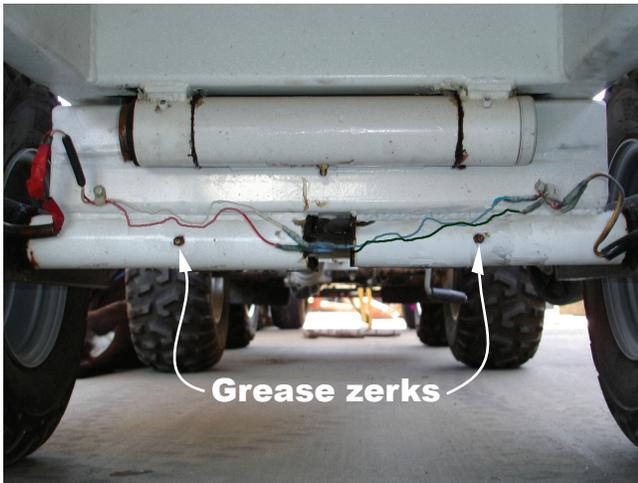


Figure 4 –Upper frame tilt mechanism. See electrical lines to brake drums and walking beam axle subassembly. Note grease zerks.



Figure 5 –Walking beam axle with individual axles for each wheel. The rear axle, in foreground, has brakes.

The upper frame consists of a pivoting frame, rails with locking pins, and a 2,500-pound-capacity electric winch mounted to the front of the frame. In addition to the pivot, the two frames are connected by a hydraulic cylinder which raises the upper frame. Each module, such as the sprayer or dump trailer, is mounted on a third frame that is pulled onto the upper trailer frame by the electric winch and secured by four pins. See figure 6.

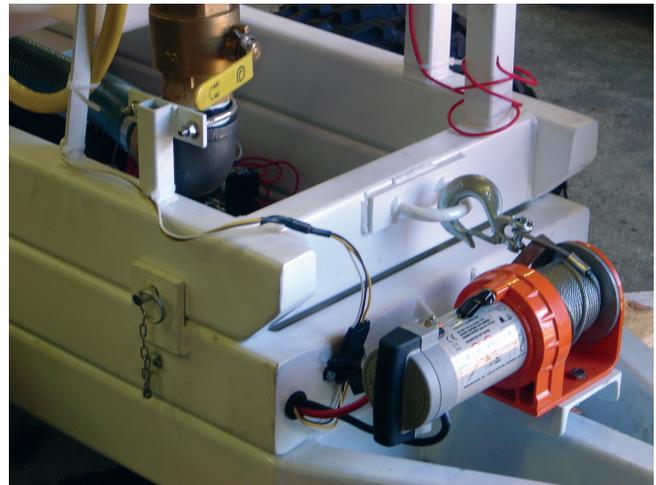


Figure 6–Pins hold third frame in place over upper frame. See pin with chain. An electric winch is used to lower the third frame to the ground and to pull it up onto the upper frame. Note: winch shroud has been removed for the picture.

The electric switch used to raise and lower the upper trailer frame is attached to the ATV handlebar. Electrical power to operate the winch and power the hydraulic unit is provided by the trailer battery. The trailer battery is charged by the ATV's electrical system.

All-Terrain Trail-Trailer and Sprayer Modules

Trailer Equipment and Specifications

- Hydraulic-lift trailer with roll-off.
- Trailer brakes with a locking parking brake.
- Winch—2,500-pound capacity; electric.
- Overall trailer weight—210 pounds.
- Turning radius—96 inches.
- Trailer dimensions—48-inch overall width, 96-inch overall length, 36-inch tongue length, 12-inch ground clearance.

The trailer can haul the following equipment: See figure 7.

- Tank/sprayer.
- Rock crusher.
- Wood chipper.
- Dump bed for rock, mulch, seed, logs, and bridge and building materials.
- General flatbed hauler.
- Tool trailer.
- Winch for pulling large objects onto the trailer for removal from remote sites.



Figure 7—Hauling application using dump bed module.

Fabrication

A fabricator in Los Angeles County, California, estimated \$5,500 to build the trailer. (Estimate includes steel, cutting, welding, painting, and specified parts.)

Drawings for fabrication are in appendix B.

Sprayer Module

The sprayer transports water and the other materials that can be used for applying herbicides, dust palliatives, soil stabilizers, and hydromulch. See figure 8. The sprayer module mixes and applies the materials either from a rear-mounted sprayer-bar or manually with a hose operated by an additional person.



Figure 8—Sprayer used for dust control.

Because the original off-the-shelf unit was not rugged enough for most trail conditions—and did not allow for water drafting—it was extensively redesigned to suit the demands of remote trail work. The following modifications were made to the original sprayer module:

1. Replaced all metal piping with Schedule 80 plastic pipe (same diameter).
2. Relocated the engine and pump to lower the center of gravity.

3. Used flexible pump fittings to reduce vibration and breakage.
4. Reinforced frame and fabricated more secure tank-mounting straps.
5. Strengthened braces for engine/pump, plumbing manifold, and remote valve.
6. Modified bottom drainage to allow removal of all liquids from tank and to prevent freezing.
7. Replaced all hose clamps with stainless steel smooth clamps to avoid cuts.
8. Replaced spray bar with stainless steel piping and adjustable spray fittings.
9. Replaced hose to spray bar with larger diameter clear hose to reduce restriction to the spray bar and to visually check for plugs in the hose.
10. Relocated remote-switch wiring to reduce risk of brush or branches catching the wire.
11. Modified plumbing manifold for hooking up suction line with a foot valve.
12. Added t-section to allow for two remote hoses with nozzles.
13. Rewired trailer to simplify wiring between ATV handlebar-mounted control switches, trailer, and sprayer module.

Mixtures are applied using either a rear-mounted sprayer bar or by multiple hose-and-nozzle combinations. In addition, the sprayer can be detached from the roll-off trailer bed and operated from a fixed site. See figures 9 through 13.



Figure 9—Sprayer module side view.



Figure 10—Sprayer module rear view. Note sprayer bar.



Figure 11—Front view—engine with 2-inch centrifugal trash pump with valves for spray and hydromulch functions.

All-Terrain Trail-Trailer and Sprayer Modules



Figure 12—Electrical valve used for actuating sprayer bar from ATV handlebars.



Figure 13—Multiple spray heads stored on the spray mechanism. The red, green, or blue nozzles are for different spray applications.

The sprayer works effectively to deliver liquids to remote trail locations. The sprayer's use as a hydromulcher is an additional, effective application. A major advantage in trail work is the sprayer's ability to draft from local water sources and mix dry materials into slurry onsite, through a jet-agitation process in the tank. Further testing is needed for dispersal of other fluids, such as fire suppressants.

Caution: When mixing a dry ingredient, such as PX300, it is extremely important to first fill the tank with water and then add the dry ingredient or pulp to prevent the seals in the motor from heating up.

Fabrication

Drawings for the sprayer fabrication are in appendix A.

Field Testing

The following discussion highlights the equipment's capabilities and uses.

City of Pleasanton, California, Spring 2004

This project consisted of transporting water during dry periods, spraying liquid soil stabilizers, and hydromulching a trail tread and cutslopes. Each of these operations took up to 20 round trips to laydown water or a hydromulch slurry. The hydromulching experience is discussed below.

The water tank was prefilled and the in-tank jet-agitation started. When the entire water volume was moving, a 40-pound bale of hydromulch cellulose was added slowly. The agitation continued while towing the sprayer to the job site.

The hydromulching was accomplished easily. The slurry mix was sprayed on the area's cut banks, roads, and bridge abutments using a hand nozzle with a 30-foot spray and a 20-foot spread. The extensive spread allowed laying down a large area quickly. Because a nozzle was not mounted on the tank another person was needed to aim the nozzle. Mounting a hydromulch nozzle on the tank frame and using a remote valve to actuate the spray could be a future improvement. See figure 14.

When the tank was not refilled with slurry within an hour, clear water was added to flush the pump, hoses, and valve before the hydromulch material hardened.



Figure 14—Using the sprayer to hydromulch. Tank is barely visible behind the ATV.

The sprayer's tank was filled and towed to a site when constructing under-side and sheet- drains. The tank was offloaded from the trailer by pulling the pins, raising the hydraulic ram, and using the winch to lower the self-contained sprayer module to the ground. See figure 15. The tank was used as a water source by attaching a heavy-duty garden hose or a 1-inch firehose and nozzle with a shutoff valve. The tank's pressure was regulated by adjusting the engine's revolutions per minute. The empty trailer was taken back to the staging area and the dump bed pulled onto the trailer rails and locked into place. The trailer became a dump bed to haul rock.



Figure 15— Self contained sprayer.

Interpretive Trail,
U.S. Department of the Interior,
Bureau of Land Management,
Bakersfield District, Alpaugh, California,
Spring 2005

This project consisted of excavating and backfilling 2,500 feet of trail with decomposed granite for a self-guided interpretive trail. After the initial excavation by a trail machine, 300 tons of decomposed granite was hauled using the haul-module mounted on the trail-trailer and towed by an ATV. Each trailer load weighed close to the maximum ATV-load capacity for the ATV. A lubrication flaw was found in the trailer and corrected by the addition of grease zirks, which provided the lubrication necessary for the smooth operation of the lift mechanism. See figure 16.



Figure 16— Upper frame raised with dump bed module attached.

All-Terrain Trail-Trailer and Sprayer Modules

Smithsonian Folklife Festival,
National Mall, Washington, DC,
June-July 2005

In celebration of the Forest Service Centennial, an interactive forest exhibit including an interpretive hiking trail was built on the National Mall during the annual Smithsonian Folklife Festival held under the auspices of the U.S. Department of the Interior, National Park Service. The sprayer and dump-box modules were used extensively to build the accessible trail and surrounding interactive forest. The dump-trailer module was used to haul sand, trail mix (a National Park Service proprietary mix), plants, trees, and mulch. The sprayer was used to mix and spread a heavy viscous tackifier to glue down the shredded-bark ground cover. The tackifier was a dry product that was mixed with water in the tank using the jet agitation. During the 3-week festival, the sprayer was used to water trees and plants along the interpretive trail. At the festival's conclusion, over 40-cubic yards of bark, trail mix, and building material had to be removed from the site. The dump bed trailer was integral in completing the cleanup. See figure 17.



Figure 17—Sprayer application for laying down tackifier.

Francis Marion Sumter National Forest,
Enoree Ranger District, South Carolina,
June-July 2005

This project entailed building 7 miles of trail and installing 13 fiberglass-reinforced plastic-truss bridges. The trailer and several of the attachments were used during this project. The dump bed was used extensively to haul erosion control blocks, rock, tools, bridge components, and 3-inch-wide by 12-foot-long wood decking. Approximately 300 round trips—hauling more than 100 tons—were completed without breakdown or trailer damage. The toolbox attachment transported the bridge-construction tools. The trailer's roll-off design allowed the tool-box module to be “dropped and locked” overnight at the jobsite. See figure 18.



Figure 18—Gravel dumped from the dump module at bridge approach.

Summary

The trail-trailer and sprayer—and the other mechanized tools—greatly increase the efficiency and safety of mechanized trail building.

Possible Use on Fires

It is noteworthy to mention that the sprayer, as designed, can mix and disperse materials that may be useful in fire management applications where ATVs are now carrying water in rear-mounted tanks. There are several advantages to using a roll-off trailer module in fire management. For example, the roll-off storage tank can transport retardant and water separately and mixed onsite as needed. At the destination, if needed, the tank module can be simply rolled off, detached, and left onsite. More importantly, the trailer module may reduce potential safety hazards. Certain hazards are inherent in carrying rear-mounted tanks on an ATV. A rear-mounted storage tank changes the ATV's center of gravity and has the potential to change the ATV's handling

characteristics. Reference: Wildland Fire Management Reference Manual-18, Chapter 3, rev. 1-24-05; and U.S. Department of the Interior U.S. Fish and Wildlife Service All-Terrain Vehicle (ATV) Torch Operations Guide 2005.

SDTDC's national publications are available on the Internet at:

<http://www.fs.fed.us/eng/pubs/>

Forest Service and U.S. Department of the Interior Bureau of Land Management employees also can view videos, CDs, and SDTDC's individual project pages on their internal computer network at:

<http://fsweb.sdtc.wo.fs.fed.us/>

For additional information on the trail-trailer and sprayer modules, contact Ellen Eubanks at SDTDC. Phone: 909-599-1267 ext 225. E-mail: eeubanks@fs.fed.us

About the Author. . . .

The US Department of Agriculture Reinvention Program has authorized the Enterprising of a Trails Training Program through Trails Unlimited. Cam Lockwood (proprietor) has been planning, designing, constructing and managing all types of trails and trail systems for the past 26+ years. Cam is considered one of the "Old Ones"—he and his team of retired and current trail experts have decades of experience in "On the Ground" problem solving of difficult trail design, construction, maintenance and reconstruction situations.

Cam Lockwood is a founding member of the National Trail Training Partnership (NTTP), a Master Performer for trails and a member of the US Forest Service National Core Team for Trails. Trails Unlimited Team members have helped write the National Trail Contract, Standards and Drawings. They have also helped with the production of several trail program videos and "Tech Tips" Technical Papers.

Trails Unlimited has developed a series of Training Modules with detailed manuals, exercises and field applications (see Training Services), and has team members and equipment ready to provide new trail construction, maintenance or reconstruction services.

Appendix A
TOWING
CAPACITIES

2007 Models Towing Capacity

Model	Weight (pounds)
Bambardier ATV	
Renegade 800 H.O. EFI 4x4	1,300
Outlander Max 800 H.O. EFI LTD 4x4	1,300
Outlander 650 H.O. EFI 4x4	1,300
Outlander 500 H.O. EFI 4x4	1,300
Outlander 400 H.O. 4x4	1,100
Rally	500
Kaswsaki	
Brute Force 750 4x4i	1,250
Brute Force 650 4x4i	1,250
Brute Force 650 4x4	1,250
Prairie 360 4x4	1,100
Prairie 360	1,100
Bayou 250	450
Susuki	
<i>Call dealer and ask about specific models</i>	
Eiger 400	400
KingQuad 700	700
Ozark 250 2x4	400
Vinson 500	400

Towing Capacities

Honda Utility ATV Towing Capacities 2001 - 2007 Model Years

	2001	2002	2003	2004	2005	2006	2007
Recon	500 lbs						
Recon ES	-	500 lbs					
Rancher 350	850 lbs	-					
Rancher 350 ES	850 lbs	-					
Rancher 350 4x4	850 lbs	-					
Rancher 350 4x4 ES	850 lbs	-					
Rancher 400 AT	-	-	-	850 lbs	850 lbs	850 lbs	850 lbs
Rancher 400 AT GPScape	-	-	-	850 lbs	850 lbs	850 lbs	850 lbs
Foreman 400	850 lbs	850 lbs	850 lbs	-	-	-	-
Rancher 420	-	-	-	-	-	-	850 lbs
Rancher 420 ES	-	-	-	-	-	-	850 lbs
Rancher 420 4x4	-	-	-	-	-	-	850 lbs
Rancher 420 4x4 ES	-	-	-	-	-	-	850 lbs
Foreman 450 4x4	850 lbs	850 lbs	850 lbs	850 lbs	-	-	-
Foreman 450 4x4 ES	850 lbs	850 lbs	850 lbs	850 lbs	-	-	-
Foreman Rubicon	850 lbs						
Foreman Rubicon GPScape	-	-	-	850 lbs	850 lbs	850 lbs	850 lbs
Foreman 500	-	-	-	-	850 lbs	850 lbs	-
Foreman 500 4x4	-	-	-	-	850 lbs	850 lbs	850 lbs
Foreman 500 4x4 ES	-	-	-	-	850 lbs	850 lbs	850 lbs
Foreman 500 4x4 ES Power Steering	-	-	-	-	-	-	850 lbs
Foreman Rincon 650	-	-	-	850 lbs	850 lbs	-	-
Foreman Rincon 650 GPScape	-	-	-	850 lbs	850 lbs	-	-
Foreman Rincon 680	-	-	-	-	-	850 lbs	850 lbs
Foreman Rincon 680 GPScape	-	-	-	-	-	850 lbs	850 lbs

**Polaris Utility ATV Towing Capacities
2006 - 2007 Model Years**

	2006		2007	
	towing capacity (pounds)	tongue weight (pounds)	towing capacity (pounds)	tongue weight (pounds)
Sportsman 800 EFI	1,500	150	1,500	150
Sportsman 700 EFI	1,500	150	1,500	150
Sportsman 500 EFI	1,225	120	1,225	120
Sportsman 450 EFI	1,225	120	1,225	120
Sportsman 6x6	1,500	150	1,500	150
X2 800 EFI	-	-	1,500	150
X2 500 EFI	-	-	1,225	120
X2	1,225	120		
Hawkeye 2x4	750	30	750	30
Hawkeye 4x4	750	30	750	75
Trail Boss 330	850	85	850	85
Magnum 330 4x4	1,000	100	-	-
Sportsman 500 EFI Red Flame	1,225	120	-	-
Sportsman 800 Twin EFI Browning Edition	1,500	150	-	-
Sportsman 700 Twin EFI Browning Edition	1,500	150	-	-
Sportsman 500 HO EFI Browning Edition	1,225	120	-	-
Sportsman 450 Browning Edition	1,225	120	-	-
Camo Hawkeye 300 4x4	750	30	-	-
Stealth Black 800 EFI			1,500	150
Sagebrush Green 500 EFI			1,225	120
Sunset Red Sportsman 500 X2			1,225	120
Red Hawkeye 300 4x4			750	30
Pink Phoenix			300	30

Towing Capacities

Yamaha Utility ATV Towing Capacities (pounds) 2002 - 2007 Model Years

	2002	2003	2004	2005	2006	2007
Beartracker	728	728	728	-	-	-
Big Bear IRS 400	-	-	-	-	-	904
Big Bear 400 4x4	904	904	904	904	904	-
Big Bear 250	-	-	-	-	-	728
Bruin 350 Auto 4x4	-	--	1,102	1,102	1,102	-
Bruin 350 Auto	-	-	1,102	1,102	1,102	-
Bruin 250	-	-	-	728	728	-
Grizzly 700 FI 4x4	-	-	-	-	-	1,212
Grizzly 700	-	-	-	-	-	1,212
Grizzly 660 Auto 4x4	1,212	1,212	1,212	1,212	1,212	1,212
Grizzly 450 Auto 4x4	-	-	-	-	-	1,102
Grizzly 400 Auto 4x4	-	-	-	-	-	1,102
Grizzly 350 IRS Auto 4x4	-	-	-	-	-	1,102
Grizzly 350 Auto 4x4	-	-	-	-	-	1,102
Grizzly 350 Automatic	-	-	-	-	-	1,102
Kodiak 450 Auto 4x4	-	1,102	1,102	1,102	1,102	-
Kodiak 400 Auto 4x4	1,102	1,102	1,102	1,102	1,102	-

Appendix B
FABRICATION
DRAWINGS

