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**Scientific and Technical
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Summary

An experimental investigation was conducted at the NASA Langley Research Center to measure the flow rate and trajectory of water spray generated by an aircraft tire operating on a flooded runway. Tests were conducted in the Hydrodynamics Research Facility and made use of a partial airframe and a nose tire from a general aviation aircraft as well as nose tires from a commercial transport aircraft. The effects of forward speed, tire load, and water depth were evaluated by measuring the amount and location of water captured by an array of tubes mounted behind the test tire. Trajectory angles of the side plume emanating from the tire footprint were nearly constant for the range of variables tested. The water displaced from the path of the tire footprint produced the spray pattern in close proximity to the tire, while the spray pattern farther aft was primarily influenced by the lateral wake produced on the surface of the water by the rolling tire. Increasing forward speed generally increased local water-spray flow rates, and the most concentrated flow in the spray pattern moved inboard slightly. Increased tire load decreased the local flow rates of the spray and a larger pattern resulted. Variations in water depth had a more significant effect on the flow rates at positions closer to the tire than at positions farther aft of the tire. The effect of a fuselage on the spray pattern was to move the upper water-flow regions of the spray pattern farther outboard. The addition of a wing generally caused a deflection of the spray downward, but spray was concentrated above the wing by the airflow around it as the wing was moved aft. Comparisons of spray patterns generated by a bias ply and a radial tire showed that the two were very similar in terms of the spray position as well as the flow rates in the pattern.

Introduction

All aircraft designed to take off and land on conventional runways have a requirement to operate during times when the runway is wet. Many of the effects of wet runways have long been known, such as reduced braking and cornering capability and, on flooded runways, a reduction in takeoff acceleration. The advent of large multiengine aircraft, particularly those with aft-fuselage-mounted turbojet engines, brought with it the chance of ingesting water spray thrown up by the aircraft tires into the engine intakes. If sufficient water is ingested, a jet engine can experience compressor stalls or even flameout. This stall or flameout situation can be especially dangerous if it occurs on the takeoff roll near rotation speed.

Typically, commercial aircraft certification requires that the airframe manufacturer demonstrate the capability to operate on a runway with one-half inch of standing water without experiencing any spray ingestion problems. Some aircraft have a geometry that is free of spray problems regardless of external conditions such as water depth and speed. Other aircraft have geometries that make spray ingestion a common problem that occurs over a wide range of conditions. These are the aircraft that typically must be fitted with chined tires or nosewheel spray deflectors. References 1 and 2 describe some military aircraft that have experienced water-spray ingestion and the associated engine surges or flameouts. Numerous studies have been conducted to determine whether aircraft are susceptible to water-spray ingestion, but they were typically carried out after the aircraft was built. Although the design of aircraft and engine type and location are dependent on many variables, it is desirable to configure an aircraft and its engines in a geometry that eliminates the spray ingestion potential.

The purpose of this paper is to present the results of a study conducted at the NASA Langley Research Center to determine the flow rate and trajectory of water spray generated by an aircraft tire operating on a flooded runway. Tests were conducted in the enclosed Hydrodynamics Research Facility using an electrically driven carriage capable of attaining speeds of 80 ft/sec. Effects of parameters, including water depth, tire load, and forward speed were evaluated by measuring the amount and location of water captured by a fixed array of tubes mounted on the carriage behind the test tire. Tests were conducted with the carriage configured in one of three ways: (1) with the nose gear of a twin-engine, general aviation aircraft; (2) with the nose gear installed in the aircraft fuselage without a partial wing; and (3) with the nose gear installed in the aircraft fuselage with a partial wing mounted at two fore-and-aft locations. Test were also conducted with the nose tires of larger commercial transport aircraft to determine the effect of radially constructed tires on the generated spray pattern compared with conventionally constructed bias-ply tires.

Apparatus

Test Facility

Tests were conducted in the Hydrodynamics Research Facility at the Langley Research Center. The facility consists of a 2900-ft-long enclosed water tank approximately 12 ft deep and 24 ft wide. A schematic of the tank section is shown in figure 1. A set of rails spaced 20 ft apart support an electrically driven carriage (fig. 2), which can traverse the entire length of the tank. Eight 75-hp motors receive power through a set of electrical trolley wires and drive eight pneumatic truck tires, which support the 18-ton carriage. A closed-loop feedback control system allows the carriage operator to select and maintain a test speed within ± 0.5 ft/sec. A more detailed description of the facility can be found in reference 3.

For this investigation, water was drained from the tank, and a 4-ft-high by 1.5-ft-wide concrete runway 50 ft long was installed in the bottom of the tank with a 20-ft ramp at each end of the runway. The total length was thus 90 ft. The ramps had a 4-in. rise and were designed to smoothly load and unload the test tire and nose-gear strut, which was restrained vertically by the carriage during a test. Figure 3 is a photograph of the runway. Aluminum pans and side plates were attached along the side of the runway to provide a total water-trough width of 3 ft. The plates and pan edges were higher than the concrete runway to provide the capability of maintaining a water depth up to 0.6 in. The nose-tire centerline was positioned 27 in. from the right side dam. The runway had adjustable side dams every 5 ft, so that the desired water depth could be set and maintained by using a water hose to continuously add water to the runway.

Test Hardware

The test airframe, nose strut, and nosewheel used during this investigation were those from a twin-engine, general aviation aircraft in the 6000-lb class. The nose tire was a 6.00×6, TT, 8-ply, type III aircraft tire with a rated load of 2350 lb and was inflated to 35 psi. The unloaded tire-pressure rating for this tire was 55 psi. Initially, tests were conducted using only the nose gear, mounted on an "I" beam truss as shown in figure 4. The truss was mounted on the test carriage and was used to position the nose tire on the runway in the bottom of the tank. The upper portion of the strut was restrained vertically, and the vertical load was preset with nitrogen pressure in the strut cylinder prior to a test.

Additional tests were conducted to investigate the effect of aircraft fuselage aerodynamics on the spray pattern. For these tests, the nose gear was mounted in the fuselage, which was installed on the carriage and was restrained with guy wires. Next, a portion of the right wing was attached to the fuselage in order to examine its effect on the spray patterns. A photograph with the wing installed is shown in figure 5. The wing was later installed at a location farther aft in order to examine the effect of wing position on the spray patterns.

Tests were also conducted using a larger conventional bias-ply tire and a radial tire to determine differences in the spray patterns due to tire construction. Each tire was a 26×6.6 tubeless tire with a ply rating of 12 and a load rating of 8600 lb. An axle was fabricated and the truss shown in figure 4 was modified to permit mounting of these larger tires. Figure 6 is a photograph of one of these tires installed on the truss.

Data Acquisition

Since general trends of flow-rate and trajectory data were sought in this investigation, the most straightforward method of capturing the water spray produced by the aircraft tire was utilized. To capture the water, two different collectors were built. The first collector consisted of an 8- by 8-tube array with 3-in-tube center spacing. Each tube was a clear plastic cylinder with a 1.625-in. inside diameter and with a removable rubber stopper placed in the aft end. Figure 7 is a photograph of the first collector. The collector was mounted on the carriage behind and to the right of the test tire to sample the water spray generated by the nose tire as it ran through the flooded runway. The collector was slightly tilted with the aft end low, so that the collected water remained in the tubes during carriage deceleration. After the test, the volume of water collected in each tube was measured to give an indication of the flow rate at that position. No measurable quantity of water adhered to the tube walls after a test. A video camera was mounted to the right and forward of the nose tire but looking aft, and if it showed that a complete sampling of the spray was not obtained, the collector was repositioned and the test was repeated to provide a larger area of spray sampling. Often, four or more collector locations were needed to completely define the water-spray pattern at a given distance behind the tire.

Later in the test program, a larger water collector was fabricated with a 22- by 22-tube array with the same spacing as the previous array. The larger collector significantly reduced the time and number of tests required to define the water-spray pattern within a plane and was more accurate because it is difficult to duplicate test conditions for successive runs exactly. Figure 8 is a photograph of the larger collector.

Additional data were obtained using high-speed movie film in cameras mounted both onboard the moving carriage and along the side of the runway aimed at the test wheel. The movie coverage was helpful in defining the trajectory of the water spray relative to the ground.

Testing Technique

The test runway used in this investigation was located approximately 1200 ft from one end of the towing tank to allow sufficient distance for the carriage to be accelerated to the desired test speed prior to traversing the runway. Prior to each test, water depth was checked and time was allowed for the water level to return to the selected test depth. Normally, the general aviation nose tire was inflated to 35 psi, and the desired tire load for the test was preselected by charging the upper strut to the appropriate pressure.

The water collector was positioned for each test run at a selected location on the right side of the nosewheel centerline. The water collector mounting hardware allowed it to be moved in three directions. One lateral plane aft of the nose gear would normally be surveyed before moving the collector in the fore-and-aft direction. Figure 9 is a sketch of the relationship between the tire and the three planes at which the water-spray pattern was measured.

Testing was begun with the carriage operator accelerating the carriage to the desired speed. The nose tire ran up the entrance ramp to load the tire, traversed the flooded runway, and then ran down the exit ramp; then the carriage was slowed to a stop. The water collector sampled the spray pattern during passage through the flooded runway. After the test, the carriage was moved back to the preparation area, and the water that was collected in each tube was measured and recorded. Tests involving the fuselage and wing were conducted in the same manner. Since comparison tests of the bias-ply and radial commercial transport aircraft nose tires were conducted without a landing gear strut, the axle vertical position relative to the test runway surface was varied to obtain the desired tire deflection.

Results and Discussion

Table I is a summary of the runs conducted in this investigation. The conditions for each run are included along with the coordinates showing the relationship between the center of the tire footprint and the lower inboard collector tube face. The "x" coordinate denotes the distance aft of the tire footprint center. The "y" and "z" coordinates denote the distances to the right and upwards, respectively, from the tire footprint center to the lower inboard collector tube face. The water-spray pattern and flow-rate data collected from all the test runs in this study are presented in the appendix.

Water Trajectory

Before discussing the effects of various parameters on the spray patterns produced by the aircraft tire operating on a flooded runway, an understanding of the water displacement and spray generation process in and near the tire footprint is needed. As the tire rolls through standing water on a flooded runway, the water in the path of the tire footprint must be almost completely displaced if the tire is operating below the dynamic hydroplaning speed. Some of the water is expelled forward out of the footprint in what is called the "bow wave". Extensive high-speed film taken of the bow wave showed it to be low in density. Since the bow wave must necessarily acquire a forward ground speed greater than that of the tire, the wave atomizes quite rapidly and is perceived to contribute little to the body of water that typically reaches an engine inlet. A "rooster tail", which consists of a spray directly behind the tire, is also produced. The rooster tail is made up of water expelled from the rear of the footprint or water that clung to the tire surface until it was free of the tire-runway interface. Because of the low quantity of water in this plume, the rooster tail is also considered to be insignificant in terms of a measurable spray ingestion potential by an aircraft engine.

The major contributor to the volume of water available for engine ingestion is water ejected laterally from the tire footprint or the "side plume" shown in figure 10. As water is expelled laterally from the tire footprint, it encounters an adjacent wall of water next to the tire footprint edge, which absorbs some of the lateral energy. The collision causes the original laterally moving unit of water to change direction and be thrown upwards. The next unit of water on the surface, having had lateral energy imparted to it, undergoes the same process and is thrown upwards but with less initial velocity. Such action induced by the tire produces a sheet of spray, as opposed to a circular jet, and the wake from the tire on the surface, much like that from a boat, has enough lateral energy to propel a much larger amount of surface water into the air than is in the direct path of the tire footprint. A photograph and sketch showing this wake-generated spray are presented in figure 10. The wake appears to be able to eject perhaps 5 to 10 times the volume of water that is actually in the direct path of the tire, which indicates the need to use water troughs wide enough to eliminate dam effects when performing water-spray tests. All water ejected in the side plume and its associated wake has forward and lateral velocities.

High-speed movie film from a number of tests was analyzed to define the initial trajectory angles of the side plume. A 6-in-long, 18-in-wide trough was dammed and positioned so that the tire rolled directly down its center. A high-speed camera was positioned forward of this test section to permit tracking of the initial portion of the side plume in the lateral and vertical planes relative to the ground. Another camera was placed directly to the side of the trough to allow tracking of the same portion of the side plume in the fore-and-aft and vertical planes relative to the ground. Combining the two trajectories gave a three-dimensional trajectory of the water leaving the footprint. The water spray atomized so quickly in these tests that only the initial angles and speed of the water spray were determined. These data, however, were combined with the final position of the spray, as determined by the wet concrete on the surrounding towing-tank walls, and a computer program was written to determine the ballistic trajectory of the water based on end conditions.

An analytically determined water-spray trajectory is presented in figure 11 for a speed of 40 ft/sec. The initial angles for the trajectory were 43° up from horizontal in the lateral vertical plane and 11° forward in the ground plane. Each vertical line represents time increments of 0.1 sec. The initial speed of the water leaving the footprint was approximately 66 ft/sec, although this determination was limited by the 400-picture-per-second frame rate of the high-speed camera that was used. For a range of speeds, loads, and water depths tested in the manner described previously, no significant differences in the trajectory angles were noticed.

One possible explanation for the consistency of the spray trajectory angles is related to the density and viscosity of the water. Many materials, such as sand, cement, or soil, have an angle of repose which is the maximum angle of the sides of a cone that the material will create when poured on top of itself. A similar phenomenon may be occurring when water with lateral velocity impacts its neighboring stationary wall of water and is driven upwards in the direction of least resistance. The properties of the water itself may determine these trajectory angles, rather than parameters such as forward speed, tire tread pattern, sidewall shape, or water depth.

Effects of Various Parameters on Water-Spray Patterns

Distance aft from tire. Measurements of water-spray patterns were collected at positions 31, 76, and 199 in. aft of the nose tire. Figure 12 presents typical water-flow-rate data that compare these positions at a speed of 60 ft/sec, with a load of 2500 lb, and with a water depth of 0.6 in. The value in each square represents the flow rate in hundredths of gallons per minute in that position as collected by a tube with a diameter of 1.6 in. The flow rate was determined by dividing the volume of water collected in each tube by the time required to traverse the flooded runway for each test. Since the collector tubes were installed on 3-in. centers, approximately 25 percent of the spray in any given area was collected, and the remaining 75 percent of the spray failed to be collected, hit the backboard of the collector, and fell to the ground. Also, all spray data presented are from the rear looking forward, so all trajectories are upwards and towards the right. Throughout the simulated collector grid, any square left blank denotes that no measurement was taken in that area because of physical constraints with the collector or because the water volume was lost before it could be recorded. Figure 12(d) presents a summary plot of lines that are drawn through the most concentrated region of the spray pattern and that are referred to as lines of maximum flow concentration. For all similar figures, the line of maximum flow concentration ends when the flow rate drops below 0.1 gal/min or when the water collector limits are reached. At the base of each line, the maximum flow rate obtained is shown in hundredths of gallons per minute. The ending flow rate is shown at the top of each line.

In figure 12(d), the flow concentration line 31 in. aft of the tire is very close to the 43° trajectory angle that was measured in the film studies. This line indicates that flow patterns in close proximity to the tire are probably dominated by the water spray emanating from the footprint itself. The flow concentration line for the data obtained at the 76-in-aft position shows a similar angle in the outboard region, which again indicates that the water spray originated in or very near the tire path. The lower region of the same flow concentration line shows an increased slope. This increase is probably a result of the wake having an increased influence on the spray, since it has more time to throw water upwards. The concentration line for the 199-in-aft position shows a higher slope than is seen in the two closer positions. A question arising from such plots is "Why is the line of maximum flow concentration for the aft plane so much steeper than the 43° trajectory angle detected by high-speed film?" The answer may be found by referring to the sketch in figure 10 and by assuming that the line of maximum flow concentration shown for the 199-in-position data in figure 12(d) can be discretized into three equal areas—the top right, the middle, and the lower left. The water collected at the top right was that which was directly in the path of the tire and which was thrown upwards with the most velocity. The water collected in the middle was that which originally resided near the tire path and which was thrown upwards by the wake. This water had less velocity than, and consequently did not rise as high as or disperse as much as, the water from the tire path. Finally, water collected at the lower left was perhaps the farthest out from the tire path and was thrown upwards with the least velocity by the wake. Although this discretization oversimplifies a continuous phenomenon, the end result is that the apparent angle of water spray at the collector array can indeed be different than the trajectory angle observed for any given particle of water. As the collector is moved farther aft, the wake has significantly more time to eject water upwards before it is captured; thus, the wake can dominate the spray patterns at relatively long distances aft. The flow rates at the top edge of the lines in figure 12(d) are similar, but the vertical positions only rise slightly. In figure 11, the time required for the spray to get near the apex of the trajectory is relatively short, but the time the spray "hovers" near the apex is relatively long.

Forward speed. A comparison of runs (fig. 13) shows the effect of speed, ranging from 40 to 80 ft/sec, on the water-spray trajectory and flow rates. The data are presented at a vertical plane located 199 in. aft of the nose tire with a water depth of 0.6 in. and at a vertical load of 2500 lb. Figure 13(d) contains plots of the lines of maximum flow concentration for the three runs. These lines show an increase in the spray intensity as speed is increased. Increased spray intensity results from increased available energy to eject water upwards and to impart greater energy laterally to the wake, which also sends water upwards.

The lines of maximum flow concentration also move inboard as speed is increased. Since the test geometry was identical, one explanation for this effect may be that the relationship between the acquired water velocity and the tire velocity is nonlinear.

Tire load. Tests for all speeds and water depths were conducted using tire loads of 500 and 2500 lb. These load values represent underload as well as overload conditions for this size tire with a rated load of 2350 lb. Figure 14 is a sketch of the tire sidewall profile and the associated footprint width for each load. Figure 15 is a typical comparison between the two loads at the 199-in. position aft of the tire at a speed of 60 ft/sec and at a water depth of 0.6 in. The difference between the maximum flow concentration lines is seen in figure 15(c). The concentration lines originate at the base of the collector in the same area; however, the heavier tire load condition produces a maximum flow concentration line farther inboard than does the lighter load condition. The data also show decreased localized flow-rate spread over a slightly larger area for the 2500-lb case than for the 500-lb case. One explanation for the positioning of the concentration lines is that for the higher load case the footprint is wider, and since the vehicle is moving at the same speed, some water in the path of the footprint must travel faster laterally to escape the footprint area. This increase in speed may move this region of water inboard as seen in figure 13(d). The wake lateral energy, however, may be more affected by the tire speed than by the width of the tire footprint, which would cause the lower regions of the spray to converge for the two loads tested. The difference in tire sidewall profiles for the two loads may also contribute slightly to the relative positions of the concentration lines.

Water depth. Tests were conducted using water depths ranging from 0.3 in. to 0.6 in. As stated previously, aircraft certification demonstration tests normally require a water depth of 0.5 in. Tests in this investigation at a water depth of 0.3 in. produced very little measurable spray; therefore, data at this water depth are not reported. Figure 16 shows the variations in the spray pattern due to water depth at a position 199 in. aft of the nose tire. These data were collected at a tire load of 2500 lb, at a speed of 60 ft/sec, and at water depths of 0.5 and 0.6 in. Lines of maximum flow concentration in figure 16(c) show nearly identical positions of the spray and nearly identical flow rates along each line. For the same speed and load conditions, measurable variations were obtained between the two water depths at positions closer to the nose tire, and one such comparison is presented in figure 17. The measurement position was 76 in. aft of the nose tire. Again, the lines of flow concentration in figure 17(c) show a similar position, although the magnitude of the flow rates shown are significantly higher for the 0.6-in. water depth. This difference in the magnitude of flow rates from the aft-plane data may be partially explained as follows. At the most forward planes aft of the tire, the spray is dominated by water leaving the footprint as opposed to that thrown up by the wake. The volume of water in the wake spray may not be as sensitive to water depth as the volume of water thrown up from the tire footprint itself. The wake-spray volume may be most sensitive to the lateral energy imparted to it, which masks an apparent effect of water depth.

Fuselage effects. Tests were conducted with the nose gear installed in the fuselage to determine what effect the fuselage had on the spray patterns developed. Figure 18 presents a comparison of data with and without the fuselage for a speed of 60 ft/sec, with a load of 2500 lb, and with a water depth of 0.6 in. The blank area in figure 18(b) represents the profile of the fuselage at the position of water collection, which was 199 in. aft of the tire. Figure 18(c) indicates a lower slope of the flow concentration line for the case with the fuselage installed; as expected, however, the flow rates are virtually identical. This trend can be seen for other test conditions; in general, the fuselage appears to cause the upper regions of the spray to move outboard more rapidly.

Fuselage and wing effects. Tests were conducted with a wing stub approximately 8 ft long installed in one of two fore-and-aft positions. Figure 19 is a planform sketch that shows relative positions between the nose tire, wing, and collector. Figure 20 shows the effect on the spray pattern of adding the wing in the forward position on the fuselage compared with using the fuselage alone. These data were measured 199 in. aft of the tire and at a speed of 60 ft/sec, a load of 2500 lb, and a water depth of 0.6 in. The additional blank area in figure 20(b) shows the rearview silhouette of the wing installed forward of the collector face. No significant water spray was recorded in the wing "shadow" area of the collector, and very little was collected in the region above the wing. Most of the flow that would have gone above the wing was deflected and concentrated in the tubes below the wing as shown in figure 20(b).

Figure 21 is a comparison of spray patterns between the fuselage-only tests and tests with the wing installed on the fuselage in the aft position. The data presented in the figure show the characteristic flow concentration of the deflected wake spray under the wing. More flow, however, was directed higher than in tests without the wing, and some of the water spray was apparently concentrated by the aerodynamic effects of the wing mounted in the aft position.

Comparison of Spray Generated by Bias-Ply and Radial Tires

Several tests were conducted at various speeds and tire deflections to determine the differences in water-spray patterns generated by a tire of bias-ply construction versus one of radial construction. Each tire tested was a 26 × 6.6 tubeless tire with a 12-ply rating and is representative of those used on the nose gear of commercial transport aircraft. Since the rated load on these tires, 8600 lb, was much greater than the load capacity of the test hardware, the tire pressure was reduced from the rated pressure of 185 psi to 45 psi for these tests, and the deflection was controlled by the axle vertical position within the support fixture. Two tire deflections were tested for each tire—1.0 and 1.8 in. for the bias-ply tire and 1.1 and 1.9 in. for the radial tire. Figure 22 shows a sketch of the sidewall profiles of each tire at both deflections tested. A comparison of the spray patterns generated by the two tires is shown in figure 23 for a speed of 60 fps, at a water depth of 0.6 in., and at the larger deflection value for each tire. These data were collected at the 199-in-aft collector position.

Figure 23(c) shows almost no difference in the position of the flow concentration lines, and the magnitudes of the flow rates along the spray path are generally alike. Similar results were observed for tests at the other speeds and tire deflections.

Concluding Remarks

An experimental investigation was conducted to examine the effects of various parameters on the trajectory and flow rate of water spray produced by an aircraft nose tire operating on a flooded runway. The parameters included forward speed, tire load, water depth, and water-collector distance aft of the tire. The effects of structures such as the fuselage and wing were studied as well. Most of the aircraft test hardware was obtained from a twin-engine, general aviation aircraft. Some tests were conducted to evaluate potential differences in water spray produced by bias-ply versus radial tires. The parameters were evaluated by capturing some of the spray produced by the nose tire in a collector array of tubes mounted behind it. The volume in each tube provided a measure of the flow rate at its location and allowed the spray pattern to be identified.

Film studies revealed that the classical "bow wave" and "rooster tail" elements of the spray contain much less water than the side plume and do not pose a significant engine ingestion problem. It was determined that the wake created on the surface of the water by the rolling tire ejects significantly more water than is directly in the path of the tire. For this reason, it is suggested that future spray testing be conducted in a water trough with an unobstructed minimum width of 10 times the nose-tire or gear width. Film studies also revealed trajectory angles for lateral spray with a tire footprint of 43° in the lateral vertical plane, and 11° forward in the ground plane. These trajectory angles appeared to be insensitive to variations in forward speed, tire load, and water depth, although the speed of the water particles along the trajectory increased with increasing tire speed.

The spray pattern varied as the distance aft from the nose tire was increased. The pattern close to the tire appeared to be dominated by the water actually leaving the tire footprint; at the aftmost measurement position, however, the pattern seemed to be dominated by the water ejected by the wake. The effects of increasing the speed were to move the bulk of the spray pattern inboard slightly and to increase flow rates along the spray path. The effect of increasing the load was to move the top region of the spray plume inboard and to spread the flow out over a slightly larger area. Water depth appeared to have an insignificant effect on the positioning of the spray, and very little variation in flow rate for the two water depths was observed at the position farthest aft from the nose tire. Measurements at positions closer to the tire, however, indicated significant increases in flow rates as the water depth increased.

Tests with a fuselage installed showed that flow rates were basically unchanged, but the trajectory angle of maximum flow concentration became slightly more shallow than in tests without the fuselage. The addition of a wing in a forward position on the fuselage caused virtually all the spray to be concentrated under the wing because of direct deflection. Moving the wing aft caused some spray to be concentrated above the wing, but a considerable amount continued to be deflected by the underside of the wing.

Comparisons of the spray patterns generated by a bias-ply tire and a radial tire showed that the two were similar in terms of the spray position and the flow rates in the pattern. These findings indicate that aircraft operators using 26×6.6 radial tires can expect virtually the same spray behavior as those using bias-ply tires.

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References

1. MacGregor, C. A.; and Bremer, R. J.: *An Analytical Investigation of Water Ingestion in the B-1 Inlets.* NA-73-181, B-1 Div., Rockwell International, June 1973. (Available from DTIC as AD B026 712L.)
2. Jaeger, Frederick J.: *F/FB-111 Nosewheel Tire Tests.* AFFTC-TR-74-5, U.S. Air Force, Mar. 1974. (Available from DTIC as AD B005 356-L.)
3. Brown, D. A.: *Langley Sea Water Tow Tank Facility: Description and Operation.* NUSC Tech. Doc. 6392, U.S. Navy, June 17, 1985.

Appendix

Water-Flow Rates

This appendix presents water-flow-rate data across the collector in figures A1 to A8 for various parameters. These figures, which show the influence of speed, water depth, tire load, collector location, test configuration, tire size, tire construction, tire pressure, and tire deflection on tire-generated water-flow rates, are given for the convenience of the user in studying detailed characteristics of water spray.

Table I. Summary of Test Run Conditions

Run	Water-collector coordinates, in. x	y	z	Forward speed, ft/sec	Tire load, lb	Surface water depth, in.	Test tire: Size	Inflation pressure, psi	Construction	Vertical deflection, in.	Test configurations
1	31	26.5	15.5	40	500	0.5	6.00 × 6	35	Bias ply	NA	Tire only
2				60							
3				80							
4			27.5	40	2500						
5				60							
6				80							
7			15.5	40	500	.6					
8				60							
9				80							
10			27.5	40	2500						
11				60							
12				80							
13	76	13	26	40	500	.5					
14				60							
15				80							
16				40	2500						
17				60							
18				80							
19				40	500	.6					
20				60							
21				80							
22				40	2500						
23				60							
24				80							
25	199	−1	16	40	500	.5					
26				60							
27				80							
28				40	2500						
29				60							
30				80							
31				40	500	.6					
32				60							
33				80							
34				40	2500						
35				60							
36				80							
37			46.5	80							

Table I. Concluded

Run	Water-collector coordinates, in.			Forward speed, ft/sec	Tire load, lb	Surface water depth, in.	Test tire				Test configurations
	x	y	z				Size	Inflation pressure, psi	Construction	Vertical deflection, in.	
38	199	14	16	40	500	0.6	6.00 × 6	35	Bias ply	NA	Fuselage installed
39				60							
40				80	↓						
41				40	2500						
42				60							
43				80	↓						↓
44				40	500						Fuselage + Wing forward
45				60							
46				80	↓						
47				40	2500						
48				60							
49				80	↓						↓
50				40	500						Fuselage + Wing aft
51				60							
52				80	↓						
53				40	2500						
54				60							
55				80	↓		↓	↓	↓	↓	↓
56				40	NA		26 × 6.6	45	Bias ply	1.0	Tire only
57				60							
58			↓	80							
59			46.5	80					↓	↓	
60			16	40					Radial	1.1	
61				60							
62			↓	80							
63			46.5	80						↓	
64			16	60					↓	1.9	
65			16	60					Bias ply	1.8	
66	↓	↓	46.5	60	↓	↓	↓	↓	Bias ply	1.8	↓

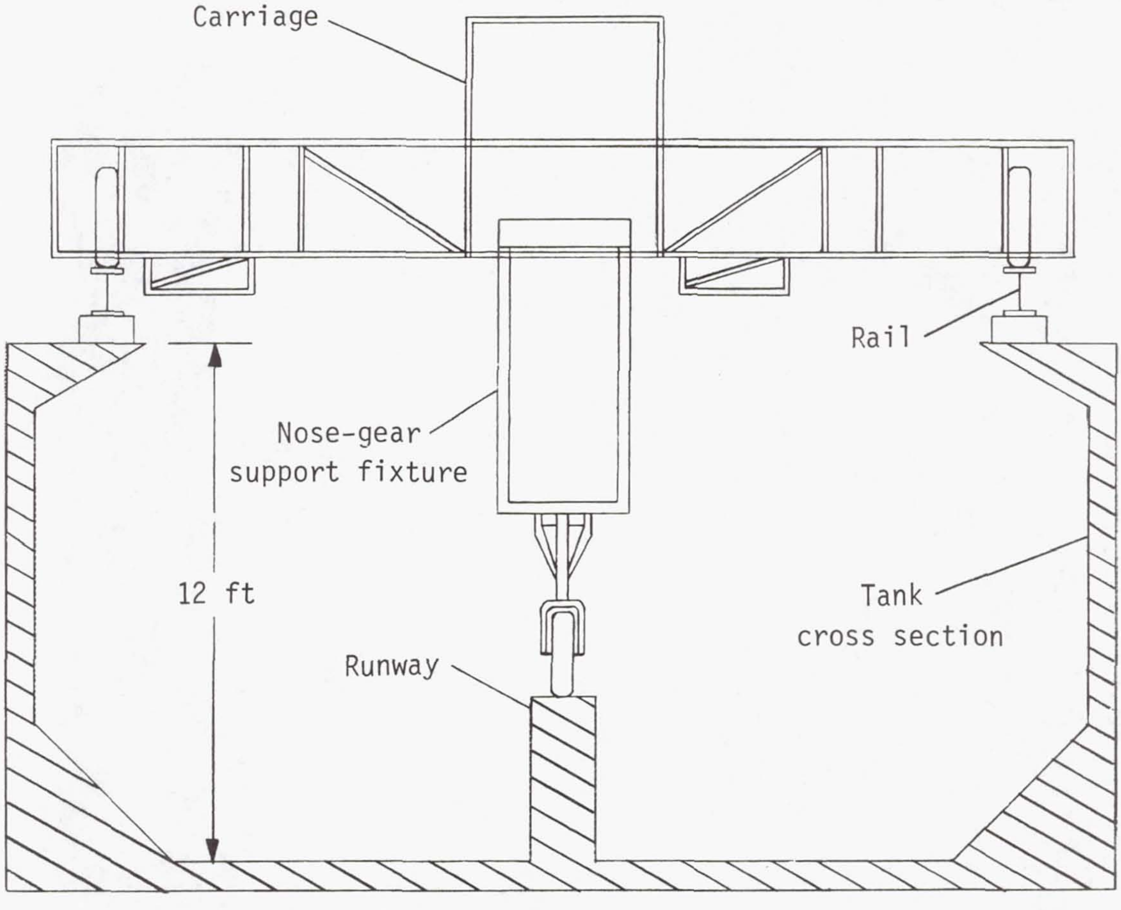
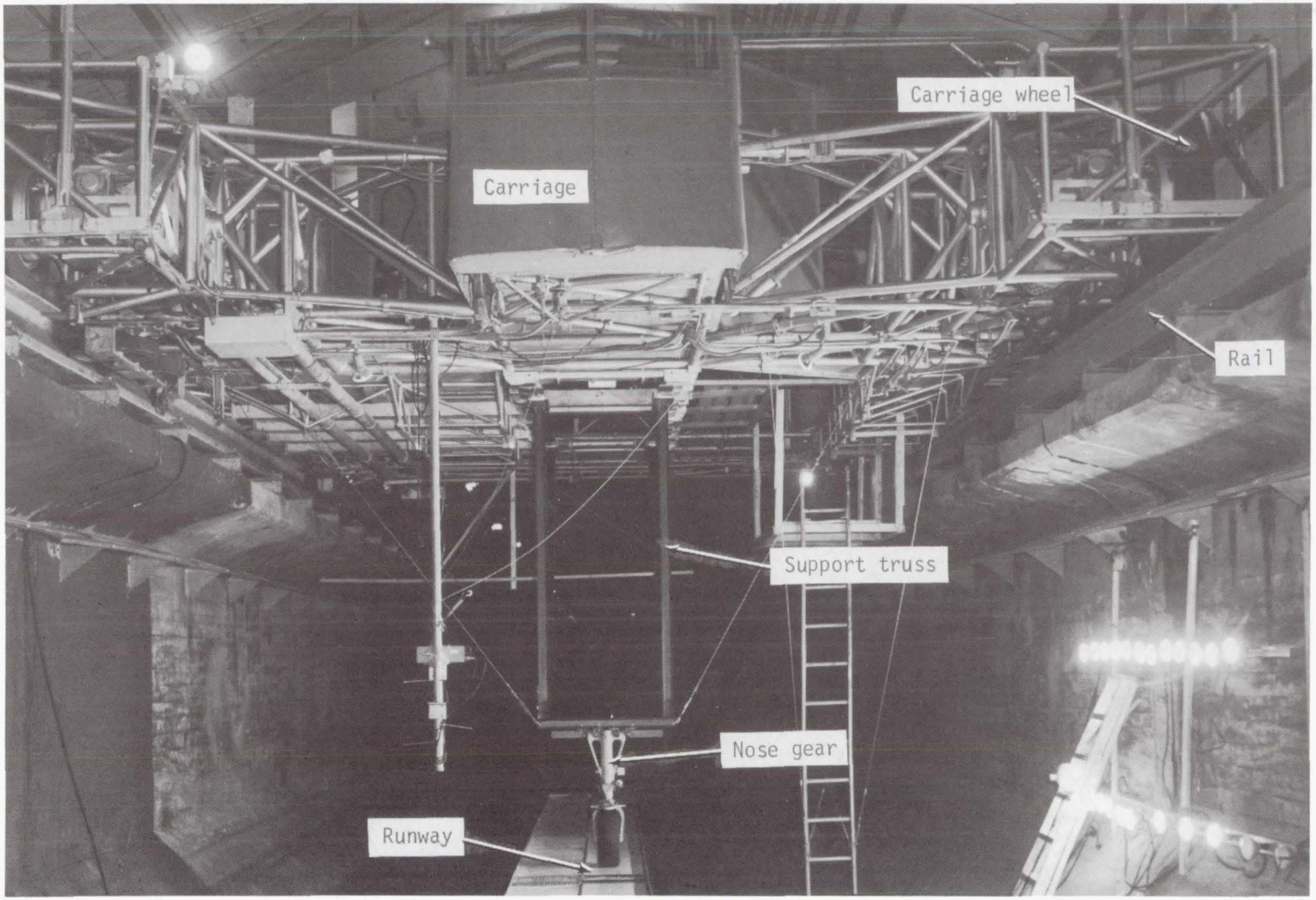
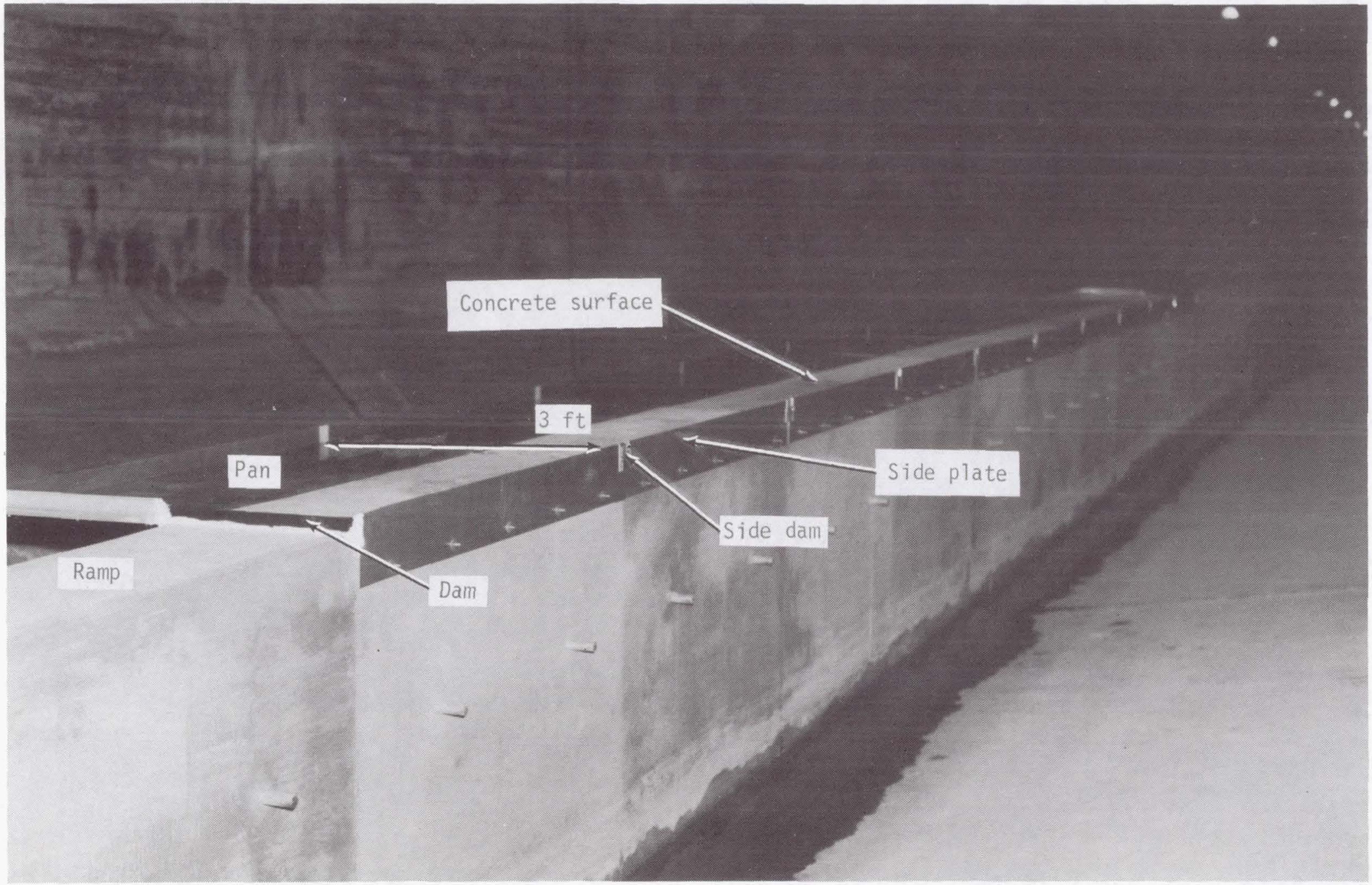


Figure 1. End view of carriage and tank.



L-84-2003

Figure 2. Front view of test carriage.

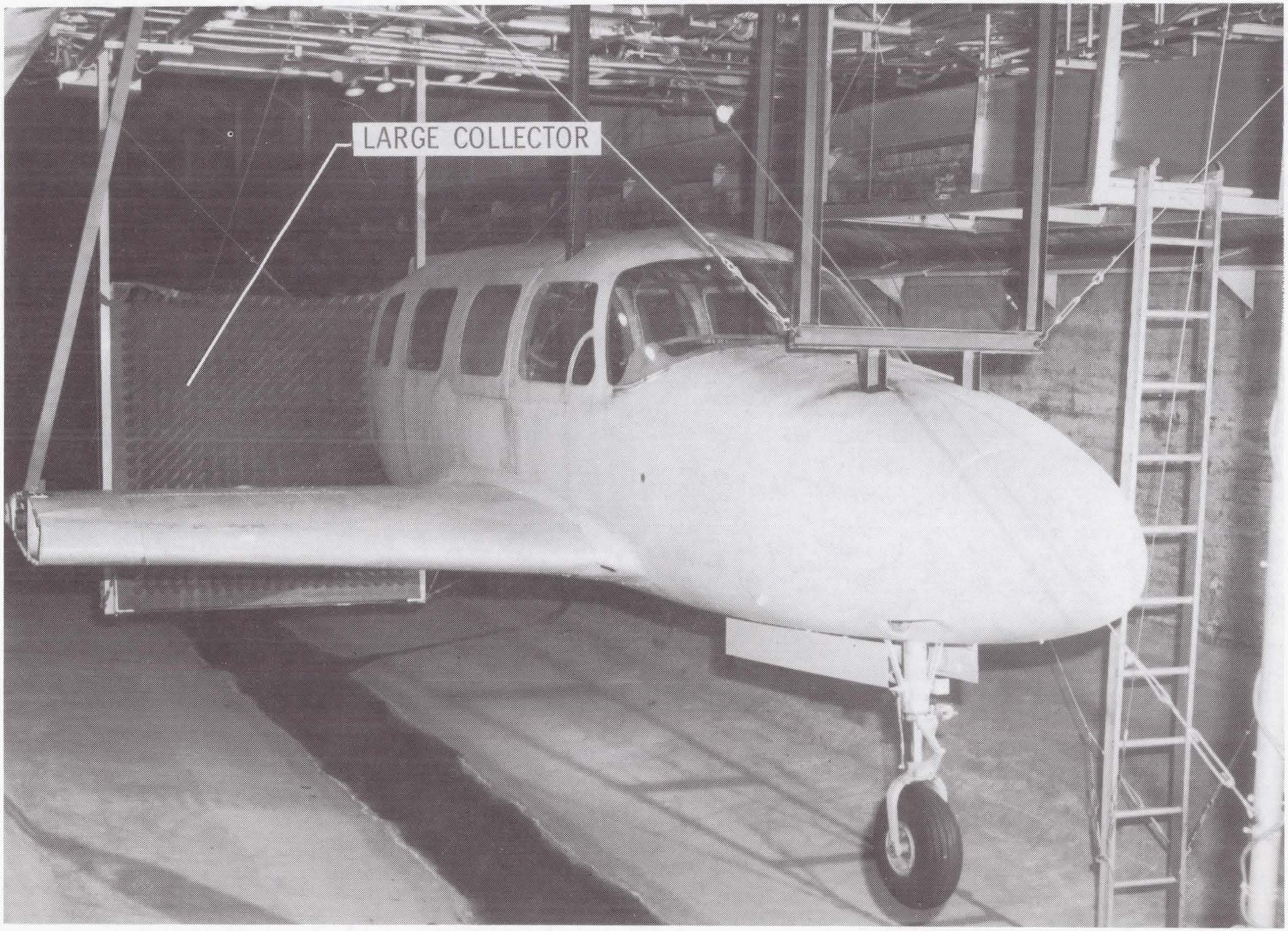


L-83-11,905

Figure 3. Test runway.

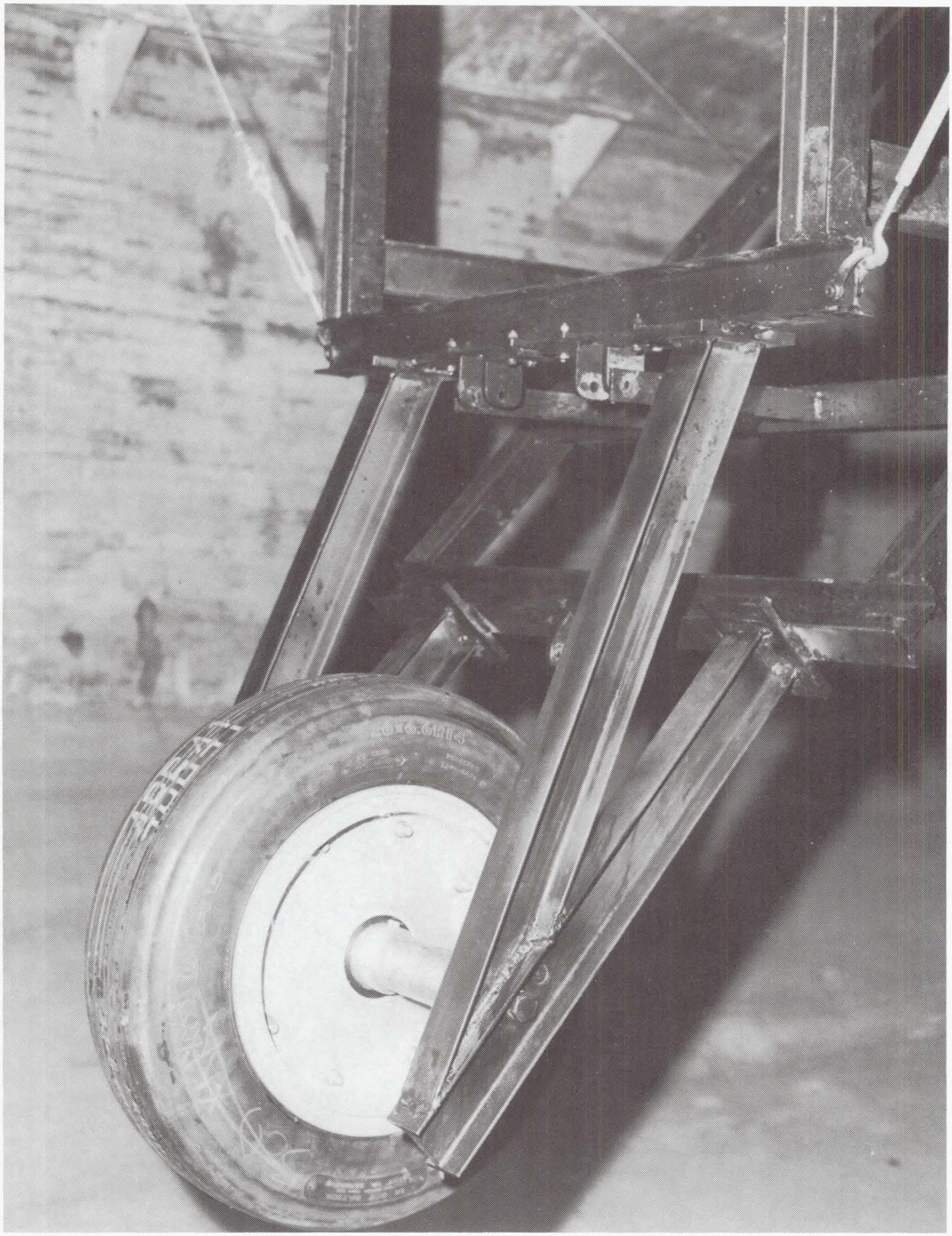
L-83-11,331

Figure 4. Nose gear and support truss prior to mounting on test carriage.



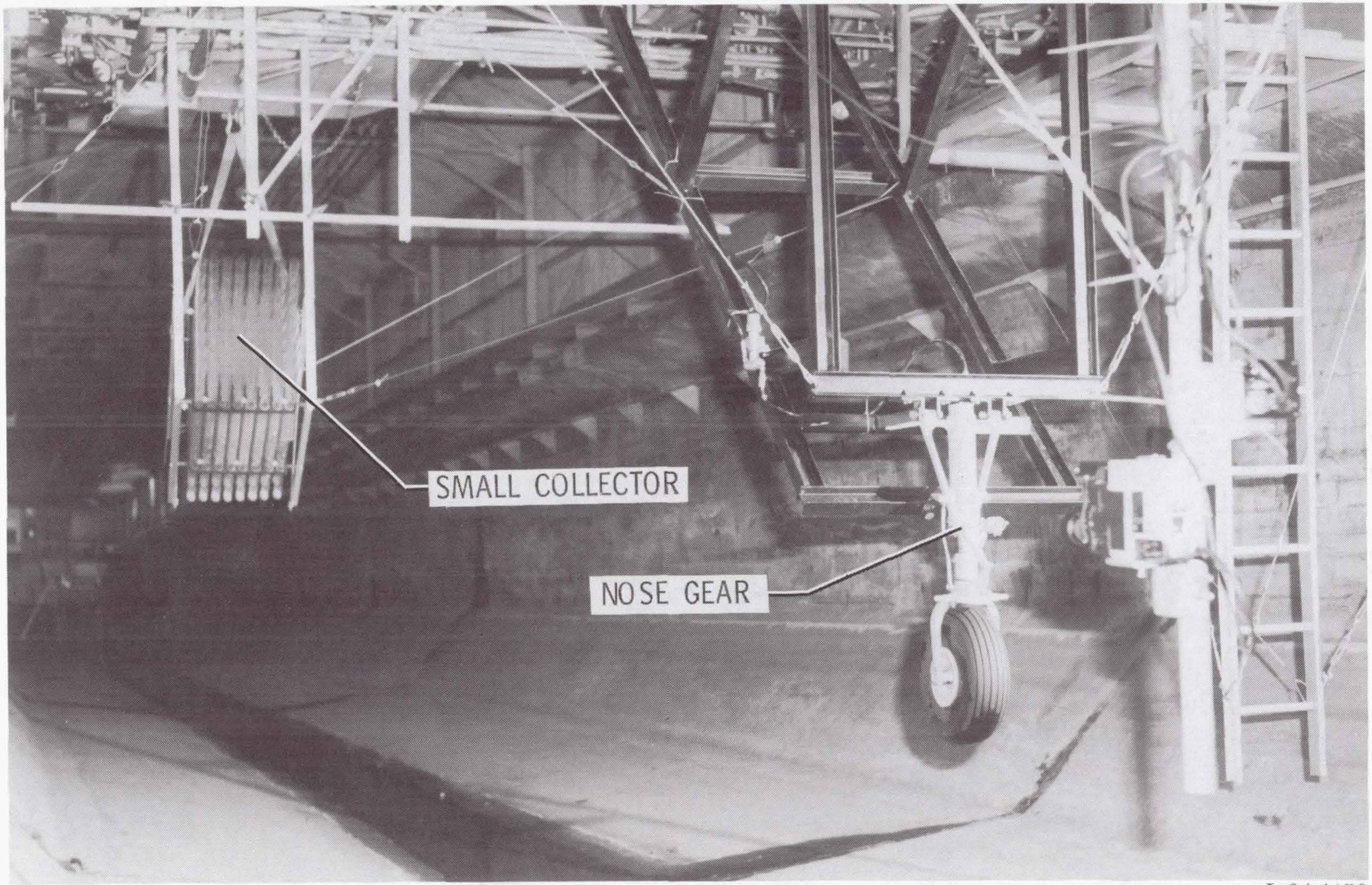
L-85-1919

Figure 5. General aviation aircraft fuselage, wing stub, and nose gear mounted on test carriage.



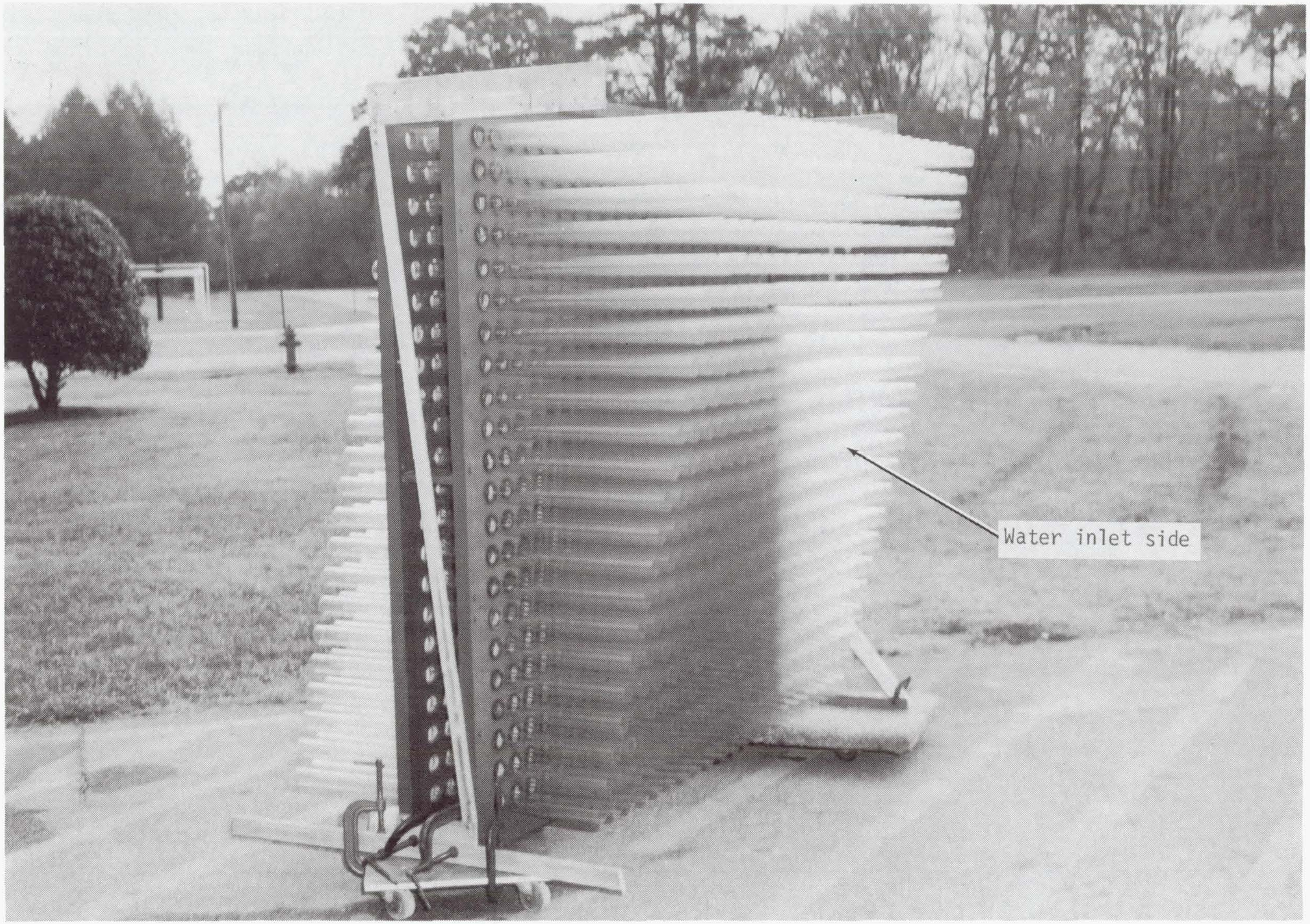
L-85-3169

Figure 6. Test configuration used with nose tire of commercial transport aircraft.



L-84-1156

Figure 7. View of water-collector array and nose gear mounted on test carriage.



L-84-12,963

Figure 8. Large water-collector array prior to installation on test carriage.

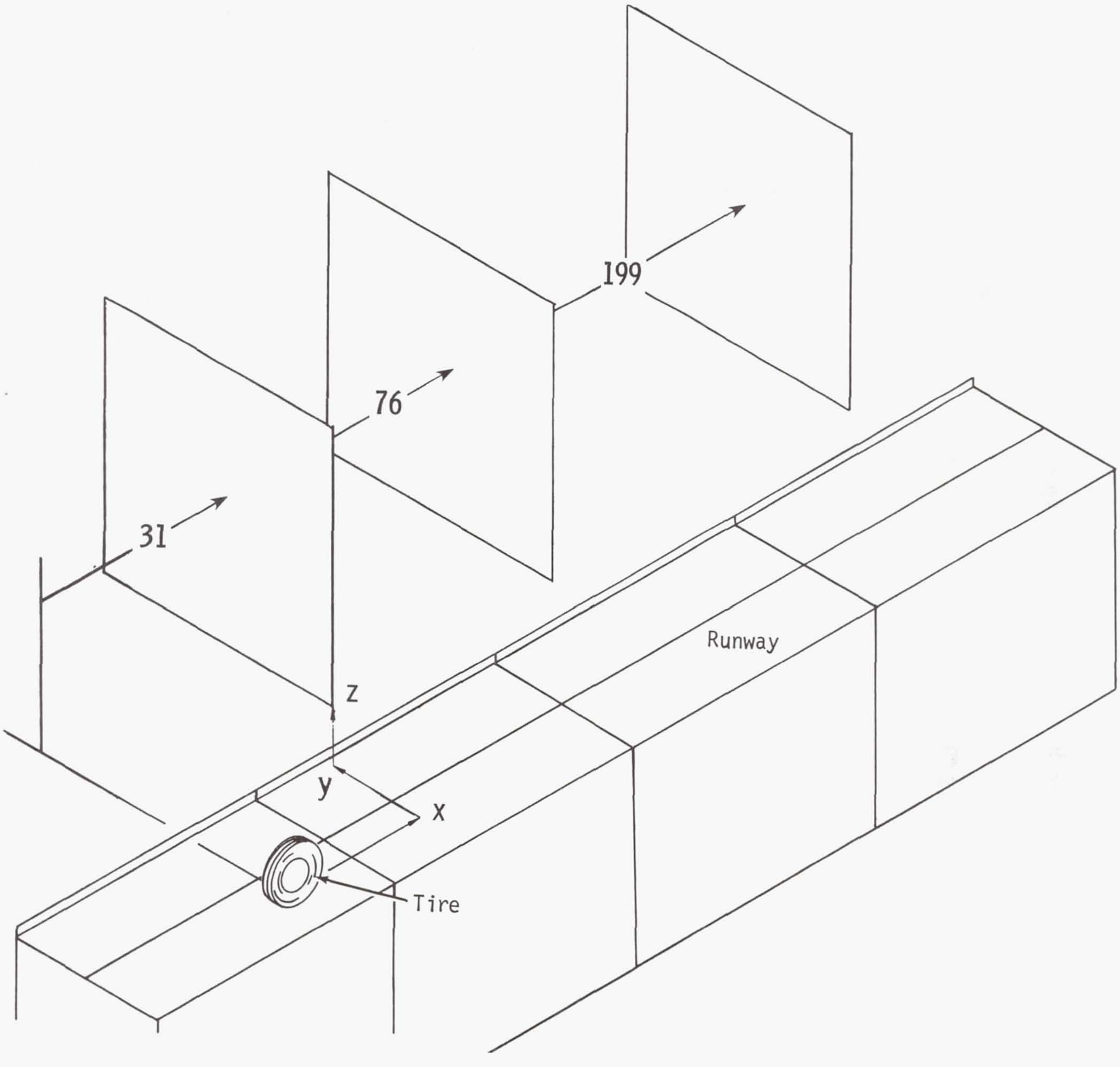
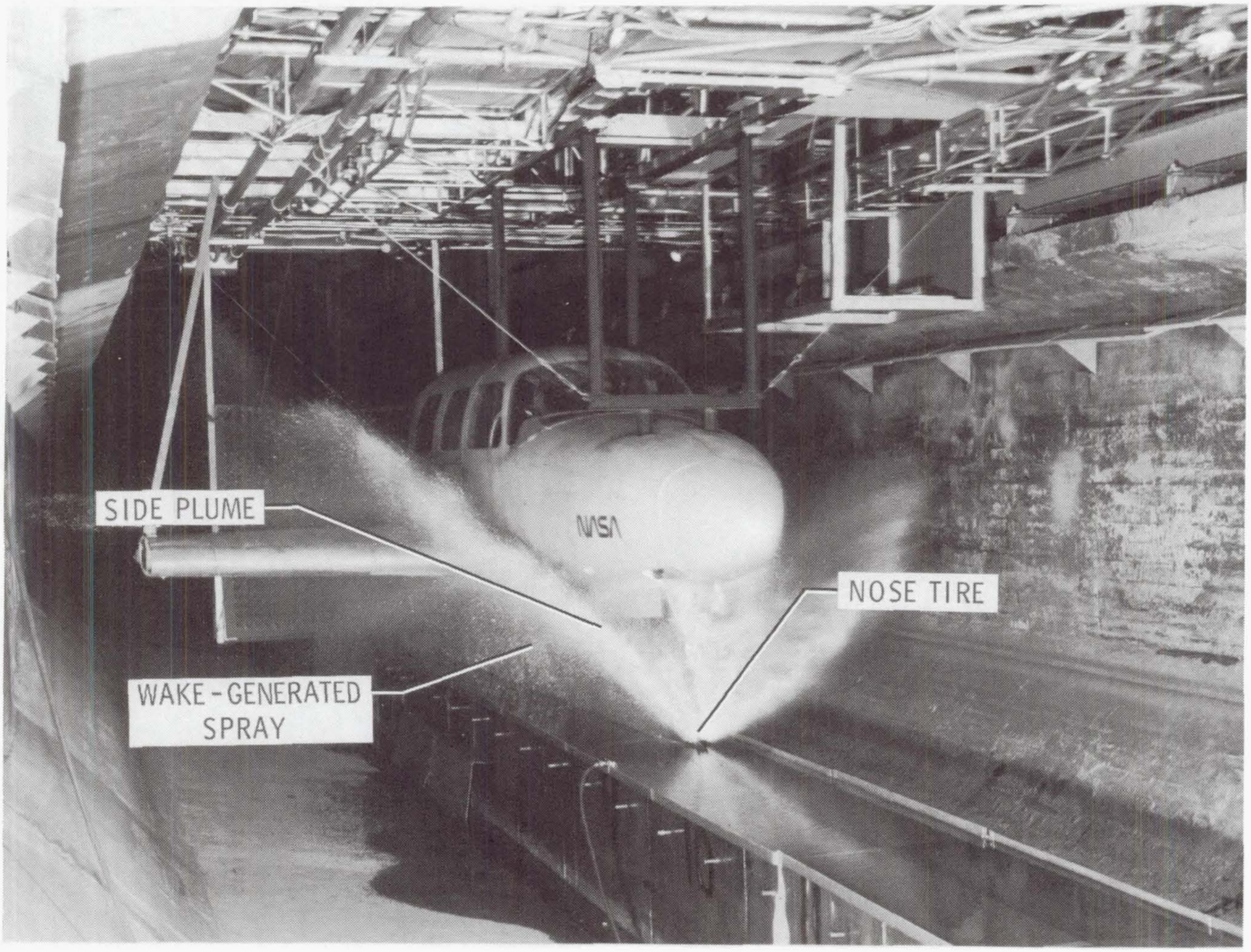


Figure 9. Test runway, nose-tire, and water-spray collector measurement positions. All dimensions are in inches.



L-87-578

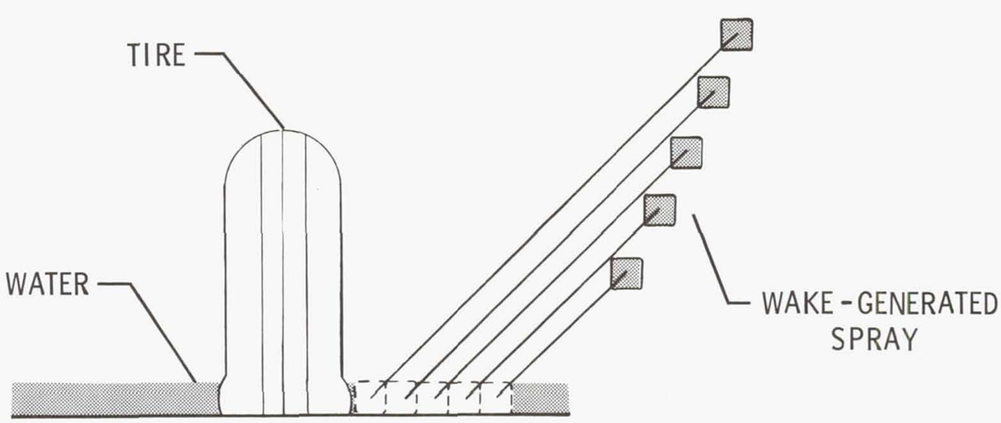


Figure 10. Photograph and sketch of water wake phenomenon.

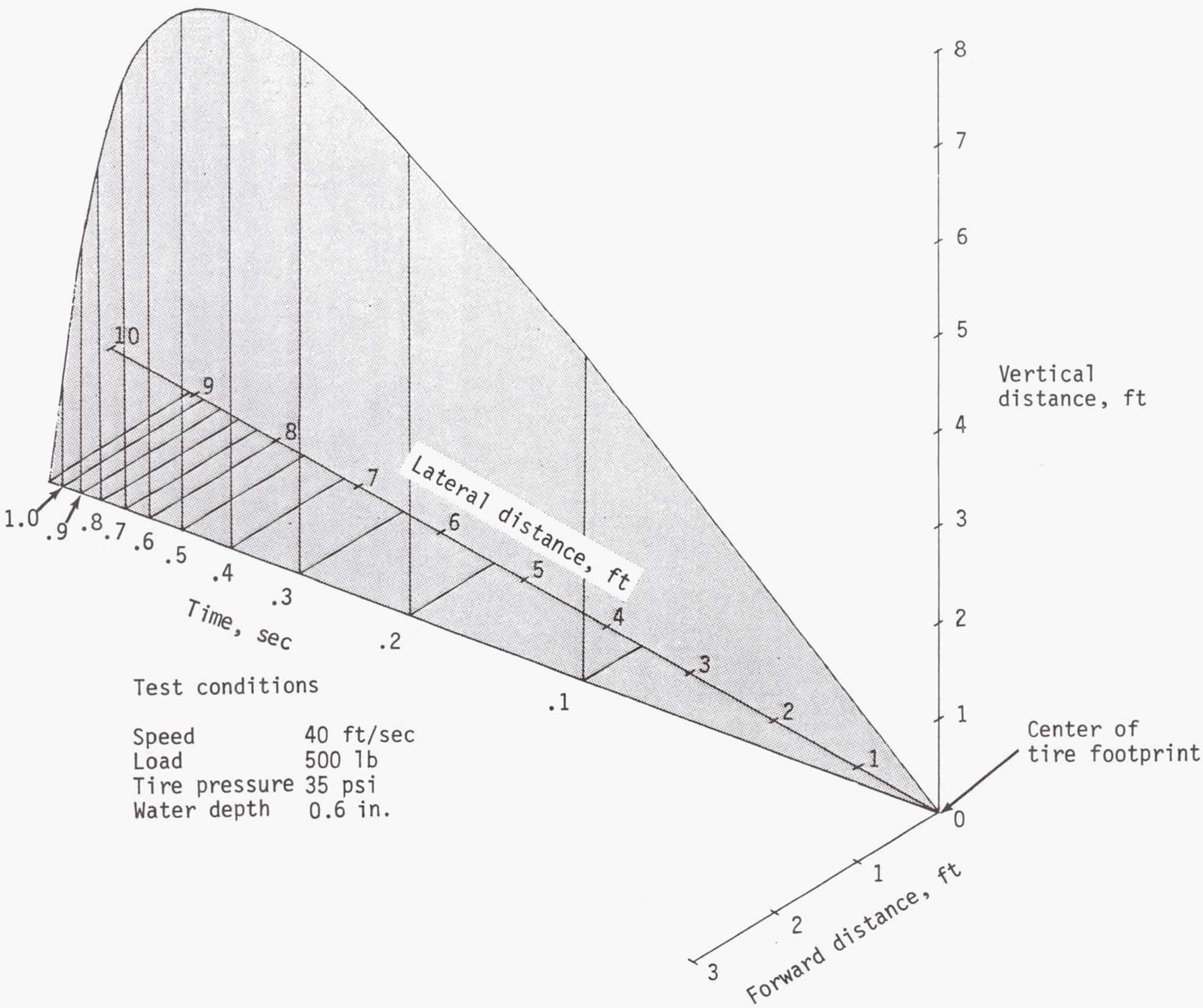


Figure 11. Water-spray trajectory from nose tire.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	4	8	11	13	15	17	17	10	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	11	13	15	19	19	17	8	0	0	0	0	0	0	0
0	0	0	0	0	0	0	4	8	11	19	23	19	13	6	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	10	15	21	25	19	11	2	0	0	0	0	0	0	0
0	0	0	0	0	0	0	10	15	21	27	23	13	6	0	0	0	0	0	0	0	0
0	0	2	4	4	4	4	15	19	23	23	17	11	2	0	0	0	0	0	0	0	0
4	4	4	6	6	8	8	17	19	25	19	11	6	2	0	0	0	0	0	0	0	0
8	10	11	13	17	15	11	13	17	19	15	8	2	0	0	0	0	0	0	0	0	0
4	13	21	25	19	15	13	10	11	10	10	2	0	0	0	0	0	0	0	0	0	0
13	27	32	23	15	13	10	13	13	8	6	2	0	0	0	0	0	0	0	0	0	0
25	34	23	15	11	10	8	11	10	6	4	0	0	0	0	0	0	0	0	0	0	0
32	19	15	11	8	6	6	6	4	4	2	0	0	0	0	0	0	0	0	0	0	0
17	13	8	6	6	4	6	4	2	0	0	2	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 31 in.   y = 26.5 in.   z = 27.5 in.

Flow values are in gallons per minute × 10^2

(a) Collector array 31 in. aft of nose tire.

Figure 12. Effect of distance aft from nose tire on spray pattern.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	2	4	6	6	8	13	13	19	0	0	0
0	0	0	0	0	0	0	0	0	0	0	2	4	8	11	15	13	21	19	0	0	0
0	0	0	0	0	0	0	0	0	0	0	6	0	6	23	21	23	19	17	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	23	25	27	4	8	15	15	0	0	0
0	0	0	0	0	0	0	0	0	0	0	27	30	27	23	19	10	13	13	0	0	0
0	0	0	0	0	0	0	0	0	0	0	30	25	21	17	13	11	8	0	0	0	0
0	0	0	0	0	0	8	11	25	32	27	23	19	17	13	11	8	8	6	0	0	0
0	0	0	0	0	0	10	34	36	30	23	15	15	11	10	8	8	6	8	0	0	0
0	11	15	21	34	48	42	38	27	23	19	15	11	8	0	0	0	0	0	0	0	0
6	13	17	30	46	65	27	30	21	17	11	8	8	6	0	0	0	0	0	0	0	0
6	13	25	42	65	82	30	21	13	11	8	6	6	6	0	0	0	0	0	0	0	0
11	19	34	67	91	80	27	15	6	0	4	6	0	0	0	0	0	0	0	0	0	0
11	21	42	91	131	89	15	4	4	4	6	4	4	0	0	0	0	0	0	0	0	0
8	29	61	114	173	68	6	2	4	6	4	4	4	4	0	0	0	0	0	0	0	0
10	32	80	171	223	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	32	114	255	249	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps Load = 2500 lb Water depth = .625 in. Tire pressure = 35 psi
Coordinates: x = 76 in. y = 13 in. z = 26 in.
Flow values are in gallons per minute x 10^2

(b) Collector array 76 in. aft of nose tire.

Figure 12. Continued.

0	0	0	0	0	0	0	2	0	2	2	6	8	8	15	13	17	15	19	13	10	8
0	0	0	0	0	0	0	2	2	2	4	6	10	17	19	23	19	19	15	10	8	4
0	0	0	0	0	0	2	2	2	6	8	11	10	19	23	21	21	17	11	8	6	2
0	0	0	0	0	2	2	4	4	6	8	13	19	27	27	25	19	19	10	0	0	0
0	0	0	0	0	0	2	4	8	8	11	19	23	27	27	49	19	8	8	2	2	2
0	0	0	0	0	0	2	4	6	10	17	25	27	30	29	30	13	6	6	4	2	2
0	0	0	0	0	2	4	6	8	13	17	27	27	34	30	29	8	6	4	2	2	2
0	0	0	0	0	2	4	6	8	11	21	34	34	40	32	21	6	2	0	0	0	0
0	0	0	0	2	2	4	4	8	17	23	32	44	46	32	13	10	2	0	0	0	0
0	0	0	0	0	2	4	6	8	19	30	38	53	55	25	11	6	4	0	0	0	0
0	0	0	0	2	2	2	6	10	17	38	48	55	48	21	10	4	2	0	0	0	0
0	0	0	0	0	2	2	4	8	19	40	63	63	46	25	10	6	2	0	0	0	0
0	0	0	0	0	2	4	8	11	27	49	59	59	42	25	6	4	4	0	0	0	0
0	0	0	0	0	2	4	10	15	32	51	63	59	25	6	6	0	0	0	0	0	0
0	0	0	0	0	0	4	8	19	48	74	57	67	19	6	0	0	0	0	0	0	0
0	0	0	0	0	2	2	13	23	42	65	51	42	11	8	0	0	0	0	0	0	0
0	0	0	0	0	0	4	15	34	63	61	42	21	11	8	0	0	0	0	0	0	0
0	0	0	0	0	2	6	25	55	74	63	53	13	4	2	0	0	0	0	0	0	0
0	0	0	0	2	4	10	32	61	95	70	38	11	6	0	0	0	0	0	0	0	0
0	0	0	0	0	2	15	40	88	84	57	19	2	2	0	0	0	0	0	0	0	0
0	0	0	0	2	6	27	80	112	99	36	6	4	0	0	0	0	0	0	0	0	0
0	0	0	0	2	6	53	124	120	80	25	4	0	0	0	0	0	0	0	0	0	0

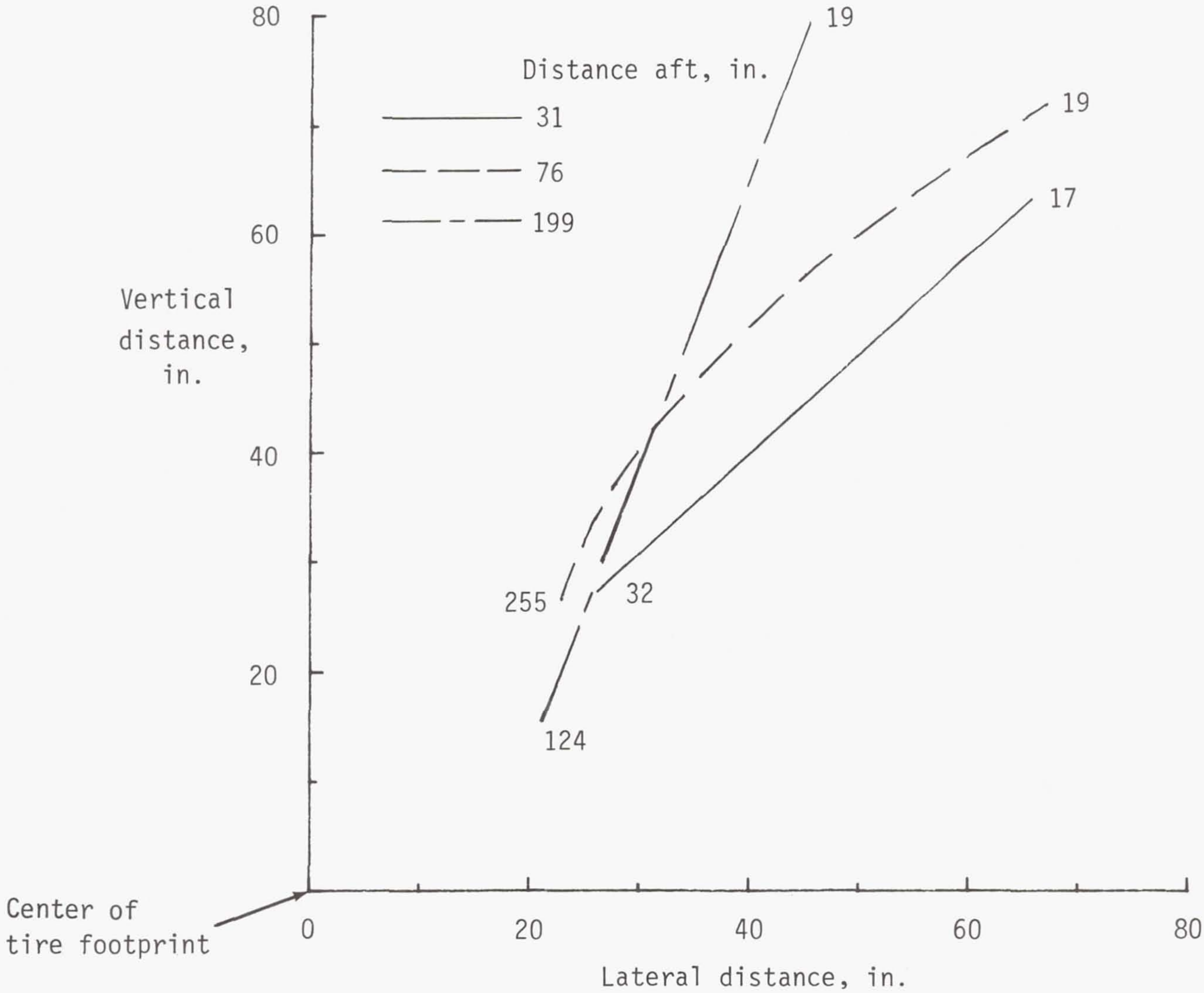
Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in. y = −1 in. z = 16 in.

Flow values are in gallons per minute × 10^2

(c) Collector array 199 in. aft of nose tire.

Figure 12. Continued.



(d) Comparison of water-spray flow concentration. (Flow concentration values are in gallons per minute $\times 10^2$.)

Figure 12. Concluded.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3	4	3	4	4
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3	3	4	4	4	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	4	4	3	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	4	6	5	5	5	5
0	0	0	0	0	0	0	0	0	1	0	1	1	3	4	3	4	4	4	4	1	3
0	0	0	0	0	0	0	0	0	0	3	1	3	3	4	5	6	5	6	4	4	3
0	0	0	0	0	0	0	0	0	1	4	4	4	5	8	6	8	5	5	4	3	3
0	0	0	0	0	0	1	1	3	3	3	4	5	6	8	6	5	5	4	1	3	1
0	0	0	0	0	1	1	1	4	4	5	5	5	9	8	6	6	4	4	3	1	1
0	0	0	0	0	0	1	4	3	4	4	13	14	11	15	10	5	4	3	1	0	1
0	0	0	0	0	1	3	3	4	4	6	8	10	11	15	9	5	5	4	3	0	1
0	0	0	0	1	1	3	4	4	6	8	11	19	13	11	6	4	4	1	1	1	0
0	0	0	0	1	1	4	4	5	9	9	11	18	15	15	9	6	4	3	1	0	1
0	0	0	0	1	1	1	1	4	8	10	24	25	16	10	8	6	3	3	1	0	0
0	0	0	0	0	1	1	3	5	9	8	20	20	23	10	6	3	1	1	0	0	0
0	0	0	0	0	0	1	1	4	8	18	29	30	24	15	5	3	1	0	0	0	0
0	0	0	0	0	1	4	5	9	13	25	34	28	22	10	4	0	0	0	0	0	0
0	0	0	0	0	1	3	4	10	16	25	32	32	22	8	1	0	1	0	0	0	1
0	0	0	0	0	1	1	5	9	15	25	34	24	15	8	4	1	1	1	1	1	0
0	0	0	0	1	1	1	4	6	24	30	34	15	13	5	0	1	1	1	0	1	0
0	0	3	0	0	0	1	3	5	24	36	28	13	5	0	0	0	0	0	0	0	0
0	0	0	0	0	1	1	3	13	28	38	23	10	4	1	0	0	0	0	0	0	0

Speed = 40 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = −1 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

(a) Speed = 40 ft/sec.

Figure 13. Effect of speed on spray pattern.

0	0	0	0	0	0	0	2	0	2	2	6	8	8	15	13	17	15	19	13	10	8
0	0	0	0	0	0	0	2	2	2	4	6	10	17	19	23	19	19	15	10	8	4
0	0	0	0	0	0	2	2	2	6	8	11	10	19	23	21	21	17	11	8	6	2
0	0	0	0	0	2	2	4	4	6	8	13	19	27	27	25	19	19	10	0	0	0
0	0	0	0	0	0	2	4	8	8	11	19	23	27	27	49	19	8	8	2	2	2
0	0	0	0	0	0	2	4	6	10	17	25	27	30	29	30	13	6	6	4	2	2
0	0	0	0	0	2	4	6	8	13	17	27	27	34	30	29	8	6	4	2	2	2
0	0	0	0	0	2	4	6	8	11	21	34	34	40	32	21	6	2	0	0	0	0
0	0	0	0	2	2	4	4	8	17	23	32	44	46	32	13	10	2	0	0	0	0
0	0	0	0	0	2	4	6	8	19	30	38	53	55	25	11	6	4	0	0	0	0
0	0	0	0	2	2	2	6	10	17	38	48	55	48	21	10	4	2	0	0	0	0
0	0	0	0	0	2	2	4	8	19	40	63	63	46	25	10	6	2	0	0	0	0
0	0	0	0	0	2	4	8	11	27	49	59	59	42	25	6	4	4	0	0	0	0
0	0	0	0	0	2	4	10	15	32	51	63	59	25	6	6	0	0	0	0	0	0
0	0	0	0	0	0	4	8	19	48	74	57	67	19	6	0	0	0	0	0	0	0
0	0	0	0	0	2	2	13	23	42	65	51	42	11	8	0	0	0	0	0	0	0
0	0	0	0	0	0	4	15	34	63	61	42	21	11	8	0	0	0	0	0	0	0
0	0	0	0	0	2	6	25	55	74	63	53	13	4	2	0	0	0	0	0	0	0
0	0	0	0	2	4	10	32	61	95	70	38	11	6	0	0	0	0	0	0	0	0
0	0	0	0	0	2	15	40	88	84	57	19	2	2	0	0	0	0	0	0	0	0
0	0	0	0	2	6	27	80	112	99	36	6	4	0	0	0	0	0	0	0	0	0
0	0	0	0	2	6	53	124	120	80	25	4	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = −1 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

(b) Speed = 60 ft/sec.

Figure 13. Continued.

0	0	3	8	8	10	10	8	10	15	18	25	33	41	43	51	48	33	28	20	13	8
0	0	5	5	5	5	8	8	10	10	15	33	36	46	51	53	51	30	23	0	0	0
0	3	3	5	5	3	5	8	10	13	23	36	46	51	58	56	43	23	13	13	8	5
3	3	3	3	3	3	3	5	8	13	25	30	46	53	63	53	61	20	10	3	0	3
3	3	3	3	3	5	5	8	10	18	28	33	48	71	71	51	28	20	3	0	3	0
3	3	3	3	3	5	5	8	13	18	33	38	51	68	71	48	23	10	3	0	0	0
3	3	3	3	3	3	5	8	13	18	33	43	96	76	66	66	15	3	3	0	0	0
3	3	3	3	3	3	3	5	10	18	36	48	79	86	68	36	13	3	3	0	0	0
3	3	3	3	3	3	3	8	13	25	38	58	91	79	56	18	8	3	0	0	0	0
3	3	3	3	0	3	5	8	13	28	48	74	91	79	43	20	0	0	0	0	0	0
3	0	0	0	0	5	8	13	18	30	53	104	96	76	28	10	3	0	0	0	0	0
0	0	3	5	5	8	10	8	13	46	66	107	94	68	28	10	3	0	0	0	0	0
3	3	3	0	3	5	8	20	15	48	81	127	76	36	18	10	3	0	0	0	0	0
0	0	0	3	3	8	13	23	33	61	101	86	68	20	13	8	3	0	0	0	0	0
0	0	0	3	3	5	10	28	38	84	112	96	46	20	10	5	3	0	0	3	0	3
0	0	0	0	3	5	10	28	61	129	74	38	10	10	3	3	0	0	0	0	0	0
0	0	0	0	3	8	20	36	86	155	155	66	23	13	5	5	3	0	3	3	0	0
0	0	0	3	3	8	30	58	152	200	104	43	23	5	3	0	0	0	0	3	3	0
0	0	0	0	5	13	38	99	218	203	79	23	5	3	3	0	0	0	0	0	3	0
0	0	0	3	8	18	66	165	274	152	36	13	10	3	0	0	0	0	0	0	0	0
0	0	0	3	10	38	101	266	304	68	20	8	3	0	0	0	0	0	0	0	0	0
0	0	3	8	15	81	228	360	172	33	5	3	3	0	0	0	0	0	0	0	0	0

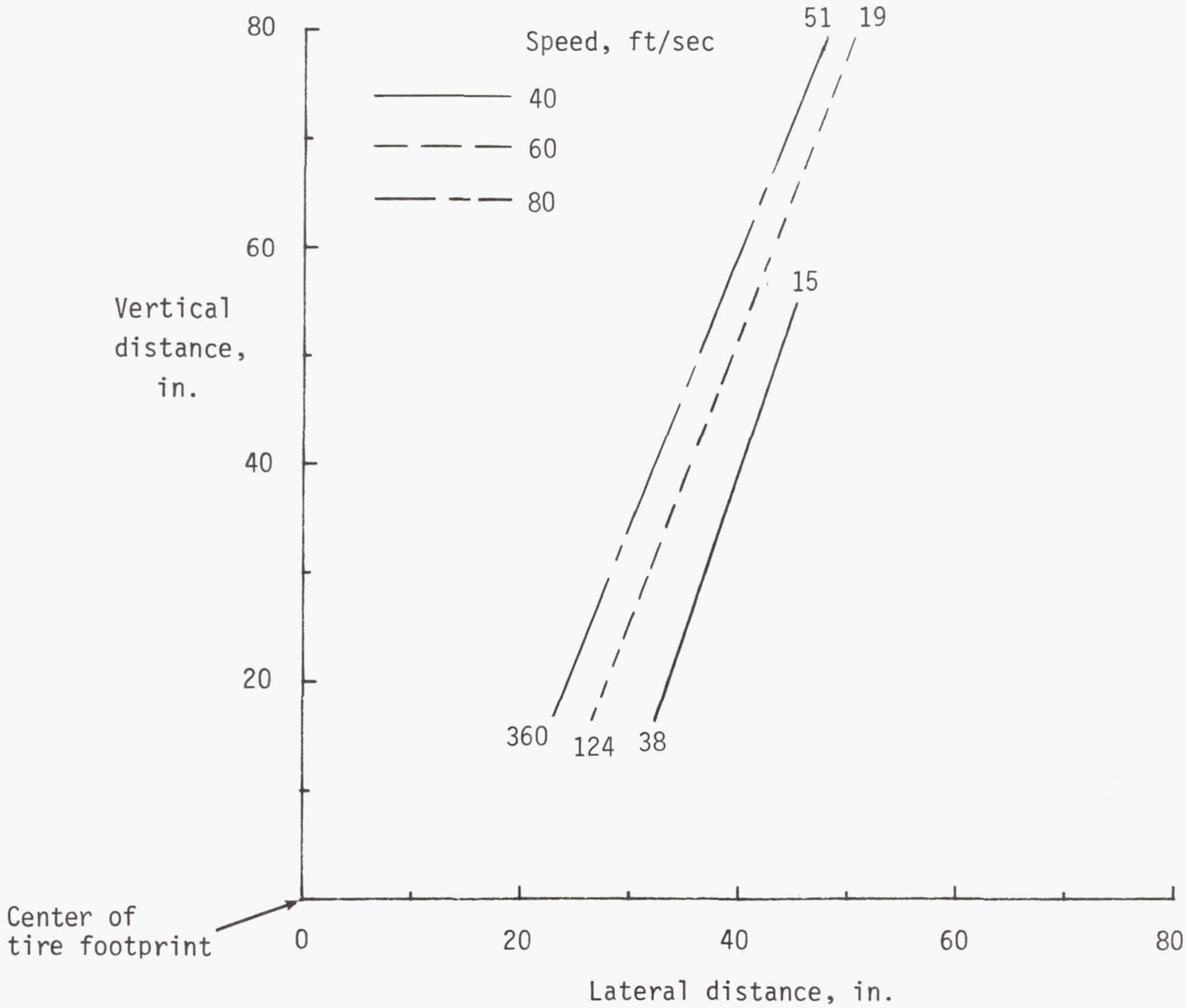
Speed = 80 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = -1 in.   z = 16 in.

Flow values are in gallons per minute × 10^2

(c) Speed = 80 ft/sec.

Figure 13. Continued.



(d) Comparison of water-spray concentration.

Figure 13. Concluded.

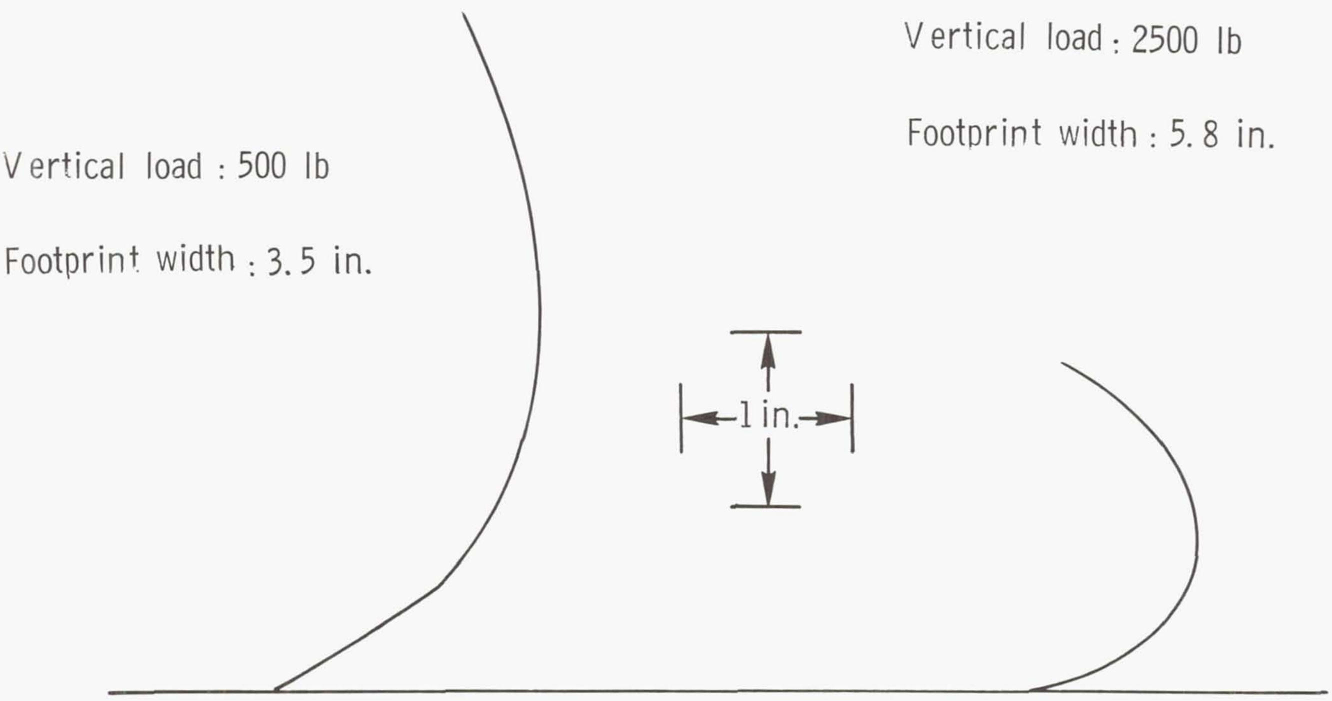


Figure 14. Sidewall profiles of 6.00 × 6, TT aircraft tire.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	4	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	4	6	6	6
0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	4	4	6	6	6	4
0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	4	6	6	6	6	6	6
0	0	0	0	0	0	0	0	0	0	0	2	4	4	6	8	10	11	8	10	8	8
0	0	0	0	0	0	0	0	0	0	0	0	2	4	6	6	8	10	13	10	6	6
0	0	0	0	0	0	0	0	0	0	2	2	4	4	6	6	8	10	11	8	6	6
0	0	0	0	0	0	0	0	0	0	2	2	4	6	10	11	8	51	42	6	6	4
0	0	0	0	0	0	0	0	0	2	2	4	6	17	25	32	48	49	44	17	10	8
0	0	0	0	0	0	0	0	2	4	4	6	13	21	32	78	80	57	29	17	6	4
0	0	0	0	0	0	0	0	2	6	6	8	15	36	67	88	97	57	25	11	8	4
0	0	0	0	0	0	0	0	4	6	6	11	17	49	74	110	89	38	19	11	6	6
0	0	0	0	0	0	2	2	2	6	6	13	29	78	95	103	49	30	11	6	6	4
0	0	0	0	0	0	0	2	4	4	6	0	76	95	133	72	17	13	10	4	4	4
0	0	0	0	0	0	0	2	4	8	19	0	40		78	21	11	10	6	2	2	0
0	0	0	0	0	0	0	4	6	15	25	114	131	76	21	13	8	6	2	2	2	2
0	0	0	0	0	0	2	4	10	29	86	162	76	27	13	2	2	2	2	0	2	2
0	0	0	0	0	0	0	8	19	72	164	110	29	10	2	2	2	0	0	0	2	2
0	0	0	0	0	0	6	15	59	118	133	42	10	2	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	25	114	205	57	11	0	0	0	0	0	0	0	0	0	2
0	0	0	0	4	17	63	194	105	13	0	0	0	0	0	0	0	0	0	0	0	0
2	2	2	2	0	0	32	148	209	27	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = -1 in.   z = 16 in.

Flow values are in gallons per minute × 10^2

(a) Vertical load = 500 lb.

Figure 15. Effect of load on spray pattern.

0	0	0	0	0	0	0	2	0	2	2	6	8	8	15	13	17	15	19	13	10	8
0	0	0	0	0	0	0	2	2	2	4	6	10	17	19	23	19	19	15	10	8	4
0	0	0	0	0	0	2	2	2	6	8	11	10	19	23	21	21	17	11	8	6	2
0	0	0	0	0	2	2	4	4	6	8	13	19	27	27	25	19	19	10	0	0	0
0	0	0	0	0	0	2	4	8	8	11	19	23	27	27	49	19	8	8	2	2	2
0	0	0	0	0	0	2	4	6	10	17	25	27	30	29	30	13	6	6	4	2	2
0	0	0	0	0	2	4	6	8	13	17	27	27	34	30	29	8	6	4	2	2	2
0	0	0	0	0	2	4	6	8	11	21	34	34	40	32	21	6	2	0	0	0	0
0	0	0	0	2	2	4	4	8	17	23	32	44	46	32	13	10	2	0	0	0	0
0	0	0	0	0	2	4	6	8	19	30	38	53	55	25	11	6	4	0	0	0	0
0	0	0	0	2	2	2	6	10	17	38	48	55	48	21	10	4	2	0	0	0	0
0	0	0	0	0	2	2	4	8	19	40	63	63	46	25	10	6	2	0	0	0	0
0	0	0	0	0	2	4	8	11	27	49	59	59	42	25	6	4	4	0	0	0	0
0	0	0	0	0	2	4	10	15	32	51	63	59	25	6	6	0	0	0	0	0	0
0	0	0	0	0	0	4	8	19	48	74	57	67	19	6	0	0	0	0	0	0	0
0	0	0	0	0	2	2	13	23	42	65	51	42	11	8	0	0	0	0	0	0	0
0	0	0	0	0	0	4	15	34	63	61	42	21	11	8	0	0	0	0	0	0	0
0	0	0	0	0	2	6	25	55	74	63	53	13	4	2	0	0	0	0	0	0	0
0	0	0	0	2	4	10	32	61	95	70	38	11	6	0	0	0	0	0	0	0	0
0	0	0	0	0	2	15	40	88	84	57	19	2	2	0	0	0	0	0	0	0	0
0	0	0	0	2	6	27	80	112	99	36	6	4	0	0	0	0	0	0	0	0	0
0	0	0	0	2	6	53	124	120	80	25	4	0	0	0	0	0	0	0	0	0	0

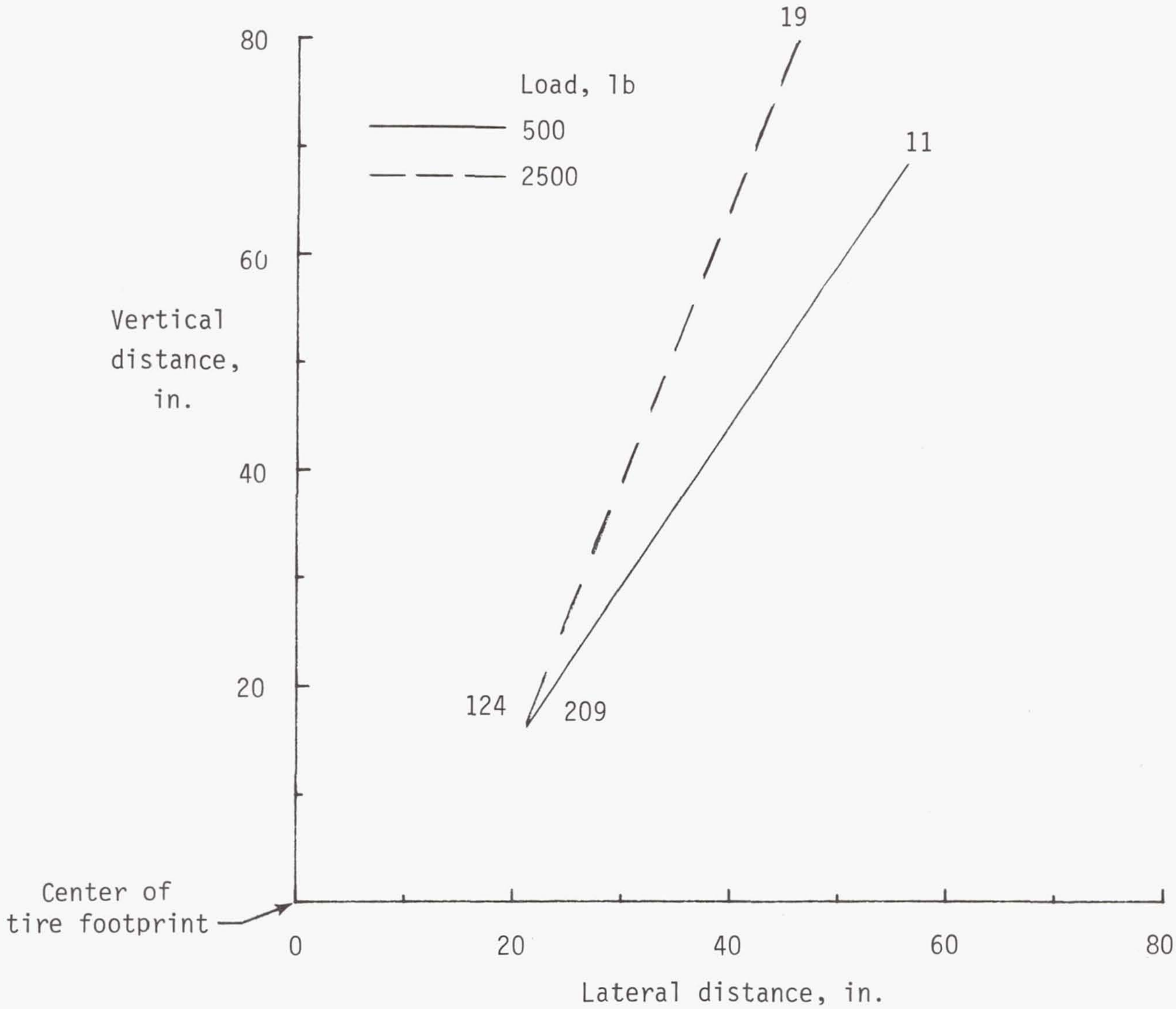
Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = −1 in.   z = 16 in.

Flow values are in gallons per minute × 10^2

(b) Vertical load = 2500 lb.

Figure 15. Continued.



(c) Comparison of water-spray flow concentration.

Figure 15. Concluded.

0	0	0	0	0	0	0	0	0	0	0	2	4	6	6	10	15	19	15	17	13	13
0	0	0	0	0	0	0	2	0	2	2	4	6	8	10	15	17	19	15	15	10	10
0	0	0	0	0	0	0	2	0	2	4	6	8	11	17	19	19	23	19	13	10	8
0	0	0	0	0	0	2	2	2	4	6	8	10	13	21	23	21	17	13	8	8	4
0	0	0	0	0	0	2	2	4	6	6	10	10	19	23	23	25	21	10	6	4	4
0	0	0	0	2	2	2	4	6	8	11	19	29	30	27	25	21	8	6	6	6	2
0	0	0	0	0	2	2	4	6	10	13	23	21	29	30	19	19	8	4	2	2	0
0	0	0	0	0	2	2	6	8	11	19	27	36	34	30	21	11	8	4	0	0	0
0	0	0	0	2	2	6	8	11	17	23	27	38	40	34	25	15	6	2	2	0	0
0	0	0	2	2	4	6	10	13	17	30	38	42	48	32	19	10	2	2	0	0	0
0	0	0	0	2	2	4	8	11	19	34	44	55	36	25	6	2	0	0	0	0	0
0	0	0	0	2	2	4	8	13	19	32	53	59	51	21	2	0	0	0	0	0	0
0	0	0	0	0	2	4	8	11	19	38	51	57	40	13	2	0	0	0	0	0	0
0	0	0	0	0	2	6	6	13	25	38	61	49	29	10	0	0	0	0	0	0	0
0	0	0	0	0	0	4	6	11	38	51	55	38	13	4	0	0	0	0	0	0	0
0	0	0	0	0	0	4	10	15	38	53	49	25	10	0	0	0	0	0	0	0	0
0	0	0	0	0	0	6	11	21	49	59	48	21	8	4	0	0	0	0	0	0	0
0	0	0	0	0	2	6	10	32	51	61	40	15	6	0	0	0	0	0	0	0	0
0	0	0	0	0	0	6	19	38	88	67	32	13	10	0	0	0	0	0	0	0	0
0	0	0	0	2	6	10	36	67	91	53	25	11	6	0	0	0	0	0	0	0	0
0	0	0	0	0	6	25	53	103	88	38	13	6	0	0	0	0	0	0	0	0	0
0	0	0	0	6	15	36	93	131	67	15	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps Load = 2500 lb Water depth = .500 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = -1 in. z = 16 in.

Flow values are in gallons per minute x 10^2

(a) Water depth = 0.5 in.

Figure 16. Effect of water depth on spray pattern measured with collector array at 199-in-aft position.

0	0	0	0	0	0	0	2	0	2	2	6	8	8	15	13	17	15	19	13	10	8
0	0	0	0	0	0	0	2	2	2	4	6	10	17	19	23	19	19	15	10	8	4
0	0	0	0	0	0	2	2	2	6	8	11	10	19	23	21	21	17	11	8	6	2
0	0	0	0	0	2	2	4	4	6	8	13	19	27	27	25	19	19	10	0	0	0
0	0	0	0	0	0	2	4	8	8	11	19	23	27	27	49	19	8	8	2	2	2
0	0	0	0	0	0	2	4	6	10	17	25	27	30	29	30	13	6	6	4	2	2
0	0	0	0	0	2	4	6	8	13	17	27	27	34	30	29	8	6	4	2	2	2
0	0	0	0	0	2	4	6	8	11	21	34	34	40	32	21	6	2	0	0	0	0
0	0	0	0	2	2	4	4	8	17	23	32	44	46	32	13	10	2	0	0	0	0
0	0	0	0	0	2	4	6	8	19	30	38	53	55	25	11	6	4	0	0	0	0
0	0	0	0	2	2	2	6	10	17	38	48	55	48	21	10	4	2	0	0	0	0
0	0	0	0	0	2	2	4	8	19	40	63	63	46	25	10	6	2	0	0	0	0
0	0	0	0	0	2	4	8	11	27	49	59	59	42	25	6	4	4	0	0	0	0
0	0	0	0	0	2	4	10	15	32	51	63	59	25	6	6	0	0	0	0	0	0
0	0	0	0	0	0	4	8	19	48	74	57	67	19	6	0	0	0	0	0	0	0
0	0	0	0	0	2	2	13	23	42	65	51	42	11	8	0	0	0	0	0	0	0
0	0	0	0	0	0	4	15	34	63	61	42	21	11	8	0	0	0	0	0	0	0
0	0	0	0	0	2	6	25	55	74	63	53	13	4	2	0	0	0	0	0	0	0
0	0	0	0	2	4	10	32	61	95	70	38	11	6	0	0	0	0	0	0	0	0
0	0	0	0	0	2	15	40	88	84	57	19	2	2	0	0	0	0	0	0	0	0
0	0	0	0	2	6	27	80	112	99	36	6	4	0	0	0	0	0	0	0	0	0
0	0	0	0	2	6	53	124	120	80	25	4	0	0	0	0	0	0	0	0	0	0

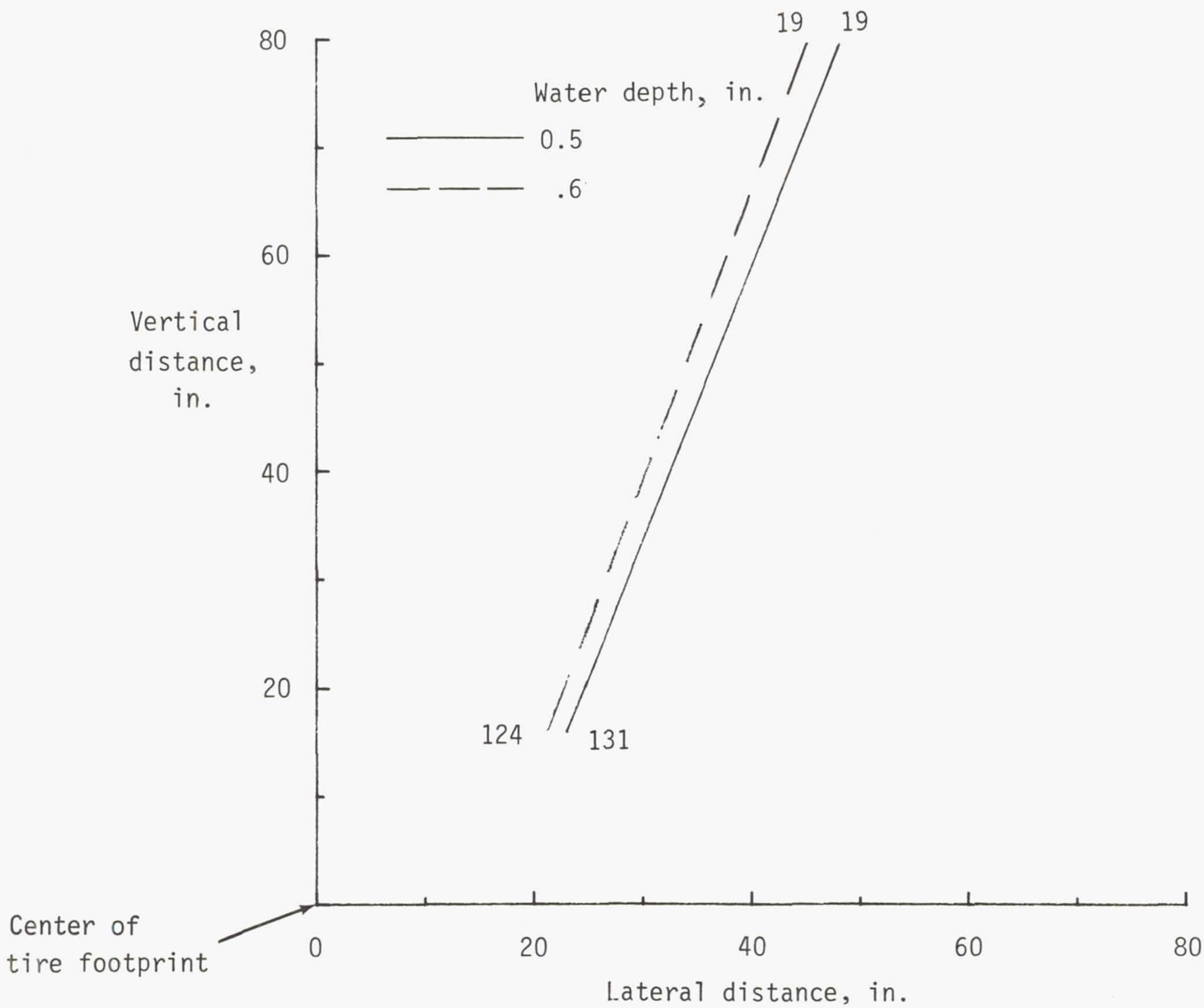
Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = -1 in.   z = 16 in.

Flow values are in gallons per minute × 10^2

(b) Water depth = 0.6 in.

Figure 16. Continued.



(c) Comparison of water-spray flow concentration.

Figure 16. Concluded.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	4	6	2	0	0	0
0	0	0	0	0	0	0	0	0	0	0	2	4	6	6	8	6	10	8	0	0	0
0	0	0	0	0	0	0	0	0	0	0	4	4	6	6	10	11	13	13	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	4	6	10	17	15	15	15	0	0	0
0	0	0	0	0	0	0	0	0	0	0	4	11	13	19	17	13	15	13	0	0	0
0	0	0	0	0	0	0	0	0	0	0	21	25	21	19	13	15	13	8	0	0	0
0	0	0	0	0	0	4	8	10	19	25	27	21	19	17	17	15	11	11	0	0	0
0	0	0	0	0	0	8	19	30	30	25	21	15	17	13	11	8	10	10	0	0	0
0	4	4	2	4	6	23	34	36	23	17	15	13	11	0	0	0	0	0	0	0	0
4	4	4	8	8	13	29	36	27	17	11	15	13	10	0	0	0	0	0	0	0	0
4	4	8	11	13	21	40	23	17	13	11	10	10	10	0	0	0	0	0	0	0	0
0	2	6	13	21	30	27	17	13	8	8	6	6	0	0	0	0	0	0	0	0	0
4	8	10	19	32	59	15	11	8	8	6	6	6	2	0	0	0	0	0	0	0	0
4	6	15	21	51	72	17	8	6	4	2	0	4	4	0	0	0	0	0	0	0	0
8	11	21	49	101	48	17	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	13	36	97	108	34	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps Load = 2500 lb Water depth = .500 in. Tire pressure = 35 psi

Coordinates: x = 76 in. y = 13 in. z = 26 in.

Flow values are in gallons per minute $\times 10^2$

(a) Water depth = 0.5 in.

Figure 17. Effect of water depth on spray pattern measured with collector array at 76-in-aft position.

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	2	4	6	6	8	13	13	19	0	0	0
0	0	0	0	0	0	0	0	0	0	0	2	4	8	11	15	13	21	19	0	0	0
0	0	0	0	0	0	0	0	0	0	0	6	0	6	23	21	23	19	17	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	23	25	27	4	8	15	15	0	0	0
0	0	0	0	0	0	0	0	0	0	0	27	30	27	23	19	10	13	13	0	0	0
0	0	0	0	0	0	0	0	0	0	0	30	25	21	17	13	11	8	0	0	0	0
0	0	0	0	0	0	8	11	25	32	27	23	19	17	13	11	8	8	6	0	0	0
0	0	0	0	0	0	10	34	36	30	23	15	15	11	10	8	8	6	8	0	0	0
0	11	15	21	34	48	42	38	27	23	19	15	11	8	0	0	0	0	0	0	0	0
6	13	17	30	46	65	27	30	21	17	11	8	8	6	0	0	0	0	0	0	0	0
6	13	25	42	65	82	30	21	13	11	8	6	6	6	0	0	0	0	0	0	0	0
11	19	34	67	91	80	27	15	6	0	4	6	0	0	0	0	0	0	0	0	0	0
11	21	42	91	131	89	15	4	4	4	6	4	4	0	0	0	0	0	0	0	0	0
8	29	61	114	173	68	6	2	4	6	4	4	4	4	0	0	0	0	0	0	0	0
10	32	80	171	223	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	32	114	255	249	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

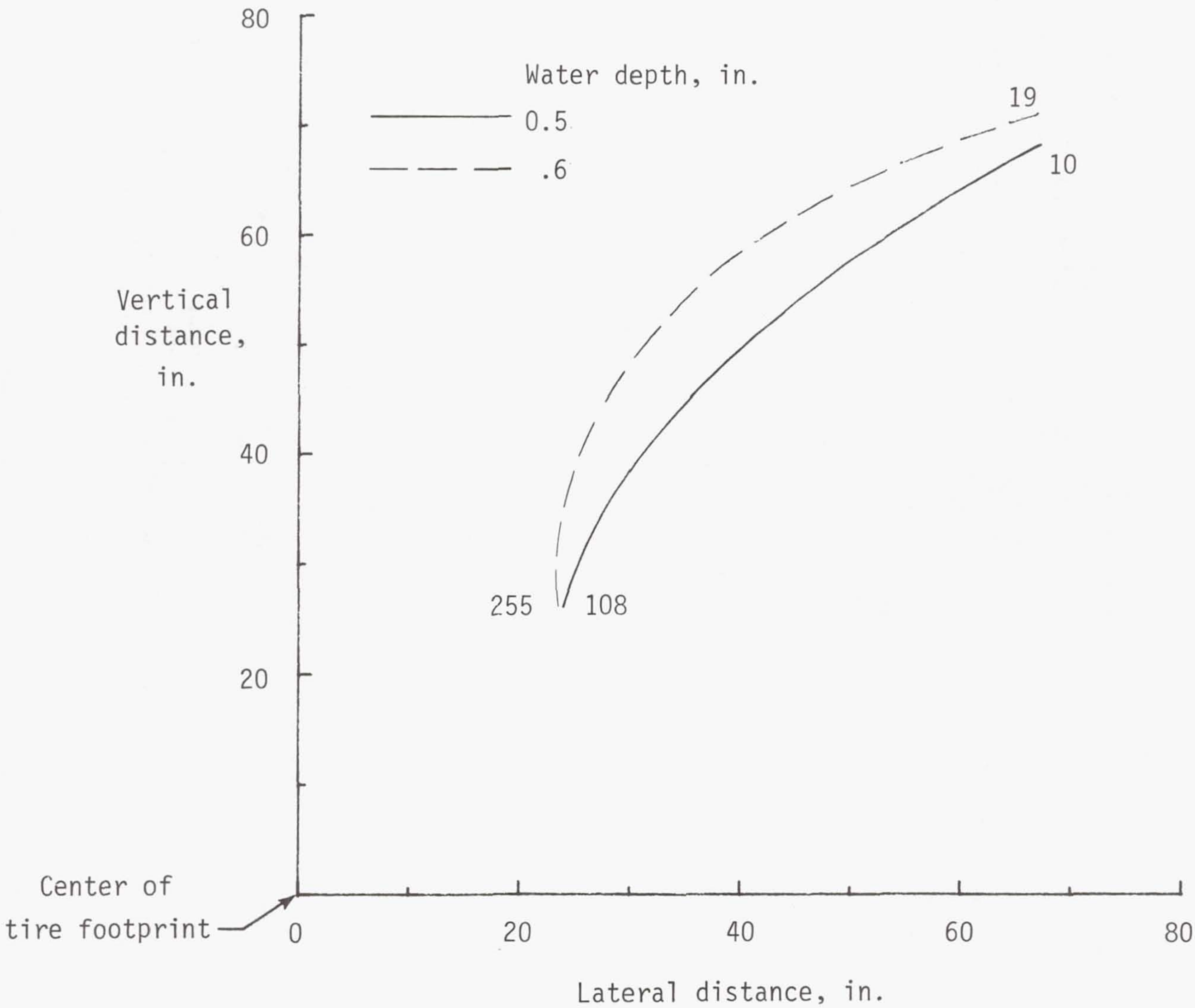
Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 76 in.   y = 13 in.   z = 26 in.

Flow values are in gallons per minute $\times 10^2$

(b) Water depth = 0.6 in.

Figure 17. Continued.



(c) Comparison of water-spray flow concentration.

Figure 17. Concluded.

0	0	0	0	0	0	0	2	0	2	2	6	8	8	15	13	17	15	19	13	10	8
0	0	0	0	0	0	0	2	2	2	4	6	10	17	19	23	19	19	15	10	8	4
0	0	0	0	0	0	2	2	2	6	8	11	10	19	23	21	21	17	11	8	6	2
0	0	0	0	0	2	2	4	4	6	8	13	19	27	27	25	19	19	10	0	0	0
0	0	0	0	0	0	2	4	8	8	11	19	23	27	27	49	19	8	8	2	2	2
0	0	0	0	0	0	2	4	6	10	17	25	27	30	29	30	13	6	6	4	2	2
0	0	0	0	0	2	4	6	8	13	17	27	27	34	30	29	8	6	4	2	2	2
0	0	0	0	0	2	4	6	8	11	21	34	34	40	32	21	6	2	0	0	0	0
0	0	0	0	2	2	4	4	8	17	23	32	44	46	32	13	10	2	0	0	0	0
0	0	0	0	0	2	4	6	8	19	30	38	53	55	25	11	6	4	0	0	0	0
0	0	0	0	2	2	2	6	10	17	38	48	55	48	21	10	4	2	0	0	0	0
0	0	0	0	0	2	2	4	8	19	40	63	63	46	25	10	6	2	0	0	0	0
0	0	0	0	0	2	4	8	11	27	49	59	59	42	25	6	4	4	0	0	0	0
0	0	0	0	0	2	4	10	15	32	51	63	59	25	6	6	0	0	0	0	0	0
0	0	0	0	0	0	4	8	19	48	74	57	67	19	6	0	0	0	0	0	0	0
0	0	0	0	0	2	2	13	23	42	65	51	42	11	8	0	0	0	0	0	0	0
0	0	0	0	0	0	4	15	34	63	61	42	21	11	8	0	0	0	0	0	0	0
0	0	0	0	0	2	6	25	55	74	63	53	13	4	2	0	0	0	0	0	0	0
0	0	0	0	2	4	10	32	61	95	70	38	11	6	0	0	0	0	0	0	0	0
0	0	0	0	0	2	15	40	88	84	57	19	2	2	0	0	0	0	0	0	0	0
0	0	0	0	2	6	27	80	112	99	36	6	4	0	0	0	0	0	0	0	0	0
0	0	0	0	2	6	53	124	120	80	25	4	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = −1 in.   z = 16 in.

Flow values are in gallons per minute × 10^2

(a) Nose wheel only without fuselage.

Figure 18. Effect of fuselage structure on spray pattern.

Fuselage profile

			0	0	0	0	0	0	0	0	0	0	2	6	11	11	11	11	11	11	11
				0	0	0	0	0	0	0	0	4	11	17	17	19	13	13	8	4	6
				0	0	0	0	0	0	0	4	19	27	21	23	21	13	6	4	4	4
				0	0	0	0	0	0	2	15	32	29	27	19	15	13	8	6	4	4
				[illegible]	0	0	0	0	0	10	49	36	30	29	21	15	8	6	4	4	2
				[illegible]	0	0	0	2	4	34	55	40	34	25	13	10	8	4	2	2	2
				[illegible]	0	0	0	2	17	57	49	36	25	15	8	4	4	2	2	2	2
				[illegible]	0	0	2	6	46	68	46	27	21	11	8	8	4	4	4	4	4
				[illegible]	0	0	4	19	82	59	34	11	11	10	10	6	4	4	2	2	2
				0	0	0	6	57	68	44	19	10	8	6	6	6	4	4	2	2	0
				0	0	0	46	82	63	23	10	10	6	4	2	2	2	2	2	2	0
				0	2	40	91	70	34	13	6	6	2	2	2	2	2	2	0	0	0
			0	0	27	76	76	42	19	6	4	4	2	2	0	2	0	0	0	0	0
		0	0	11	70	74	53	32	6	2	2	0	2	2	2	2	0	0	0	0	0
0	0	0	15	72	76	63	46	10	0	0	0	2	0	2	0	2	0	2	0	0	0
0	4	27	53	61	63	48	19	4	2	0	0	2	0	2	0	0	0	0	0	0	0
6	4	32	42	63	48	36	17	4	2	0	0	0	0	0	0	0	0	0	0	0	0
11	19	32	53	70	59	21	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0
11	21	42	76	76	42	17	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0
17	38	80	91	61	30	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	67	89	86	76	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	122	114	76	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

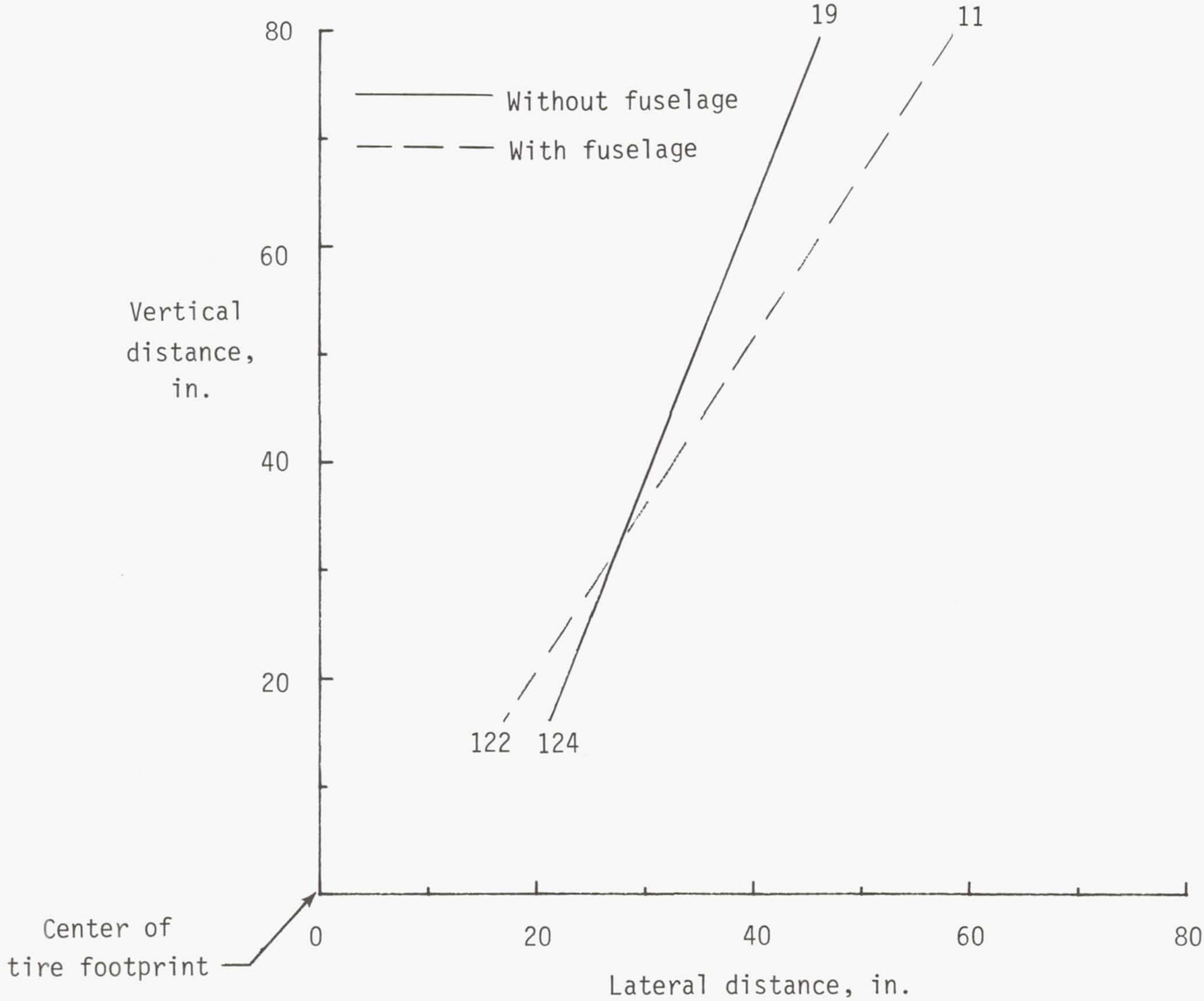
Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

(b) Nose wheel installed on fuselage.

Figure 18. Continued.



(c) Comparison of water-spray flow concentration.

Figure 18. Concluded.

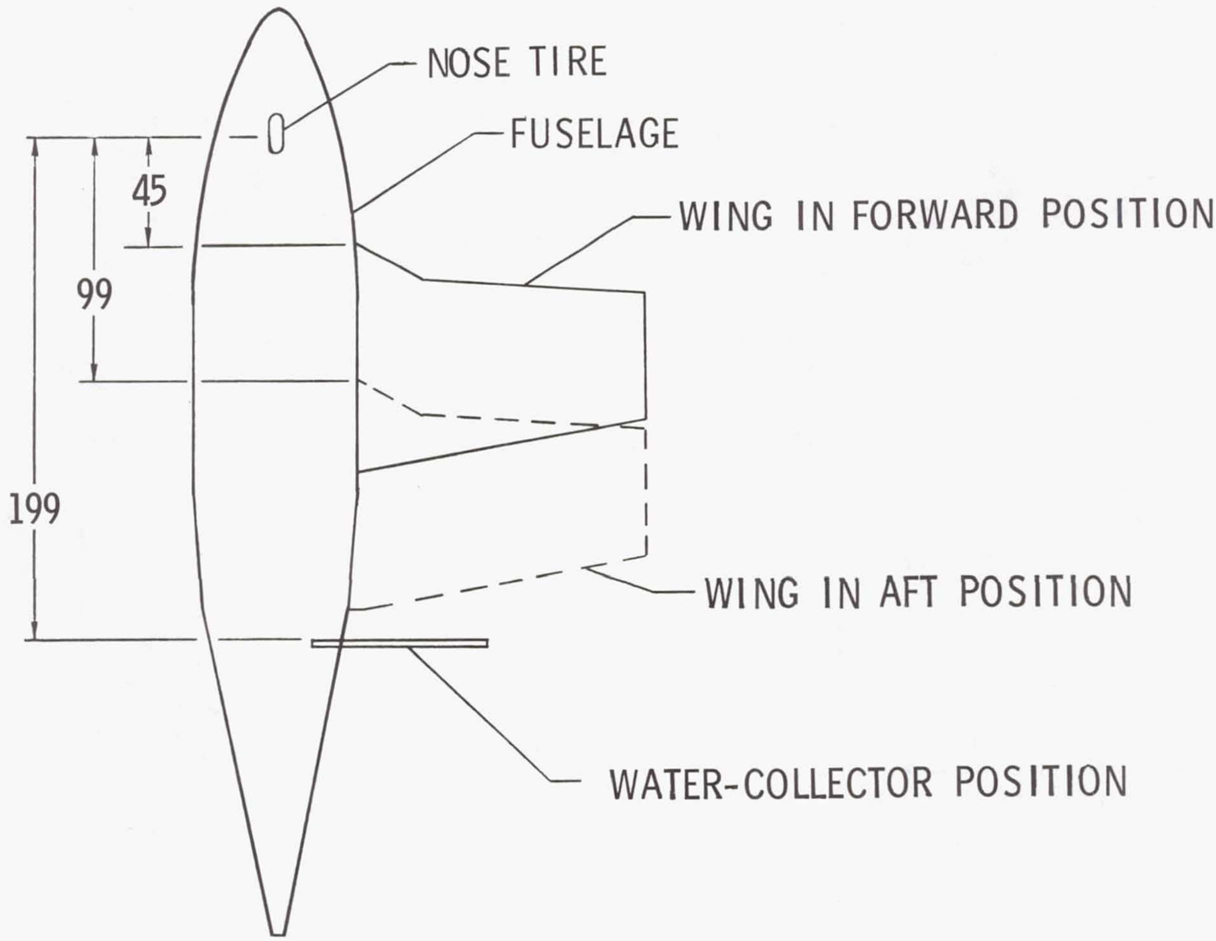


Figure 19. Schematic of fuselage, wing, and water collector. All dimensions are in inches.

			0	0	0	0	0	0	0	0	0	0	2	6	11	11	11	11	11	11	11
				0	0	0	0	0	0	0	0	4	11	17	17	19	13	13	8	4	6
				0	0	0	0	0	0	0	4	19	27	21	23	21	13	6	4	4	4
					0	0	0	0	0	2	15	32	29	27	19	15	13	8	6	4	4
					0	0	0	0	0	10	49	36	30	29	21	15	8	6	4	4	2
					0	0	0	2	4	34	55	40	34	25	13	10	8	4	2	2	2
					0	0	0	2	17	57	49	36	25	15	8	4	4	2	2	2	2
					0	0	2	6	46	68	46	27	21	11	8	8	4	4	4	4	4
					0	0	4	19	82	59	34	11	11	10	10	6	4	4	2	2	2
					0	0	6	57	68	44	19	10	8	6	6	6	4	4	2	2	0
				0	0	0	46	82	63	23	10	10	6	4	2	2	2	2	2	2	0
				0	2	40	91	70	34	13	6	6	2	2	2	2	2	2	0	0	0
			0	0	27	76	76	42	19	6	4	4	2	2	0	2	0	0	0	0	0
		0	0	11	70	74	53	32	6	2	2	0	2	2	2	2	0	0	0	0	0
0	0	0	15	72	76	63	46	10	0	0	0	2	0	2	0	2	0	2	0	0	0
0	4	27	53	61	63	48	19	4	2	0	0	2	0	2	0	0	0	0	0	0	0
6	4	32	42	63	48	36	17	4	2	0	0	0	0	0	0	0	0	0	0	0	0
11	19	32	53	70	59	21	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0
11	21	42	76	76	42	17	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0
17	38	80	91	61	30	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	67	89	86	76	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	122	114	76	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

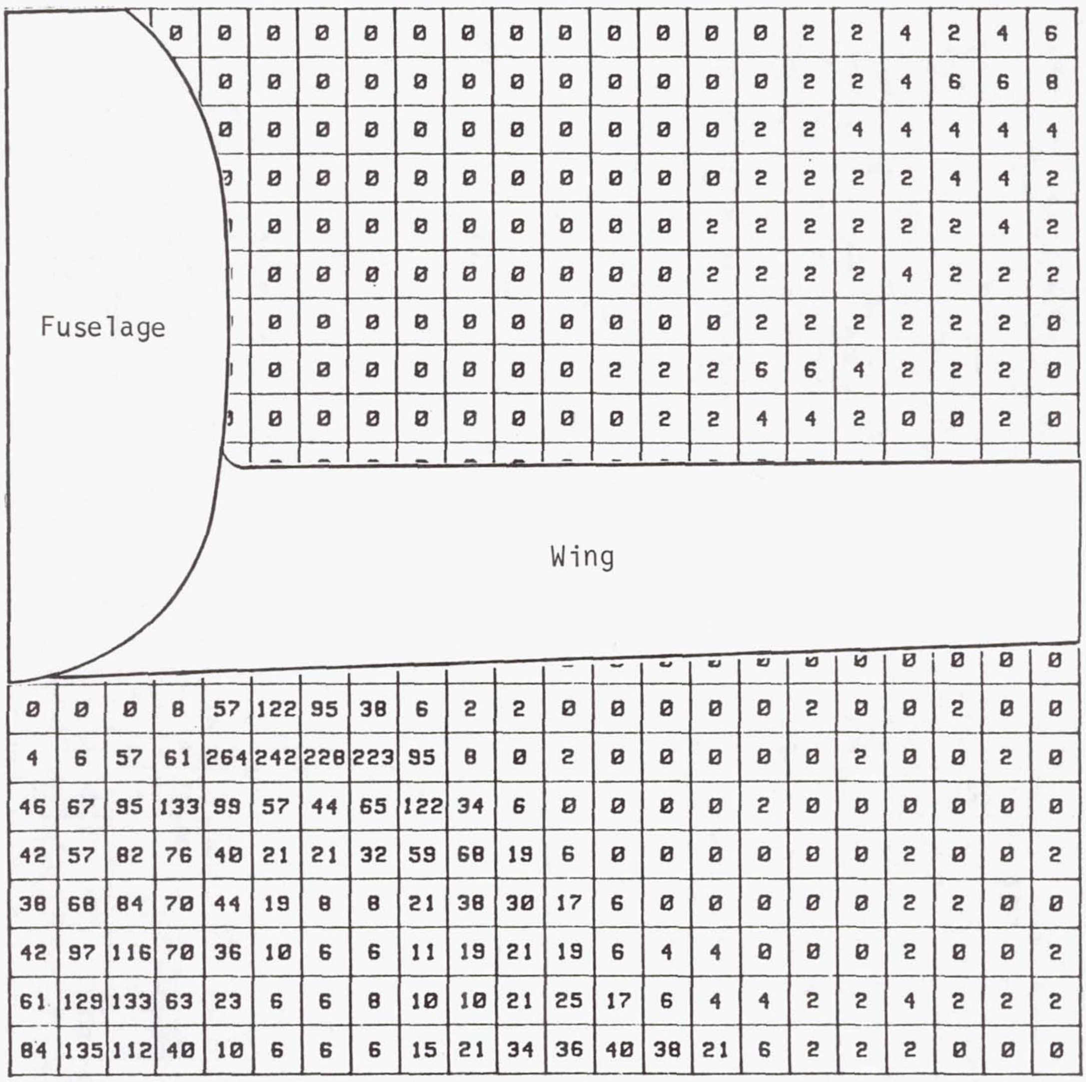
Speed = 60 fps Load = 2500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = 14 in. z = 16 in.

Flow values are in gallons per minute x 10^2

(a) Fuselage only.

Figure 20. Effect of wing in forward position on spray pattern.



Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

(b) Fuselage with wing installed in forward position.

Figure 20. Concluded.

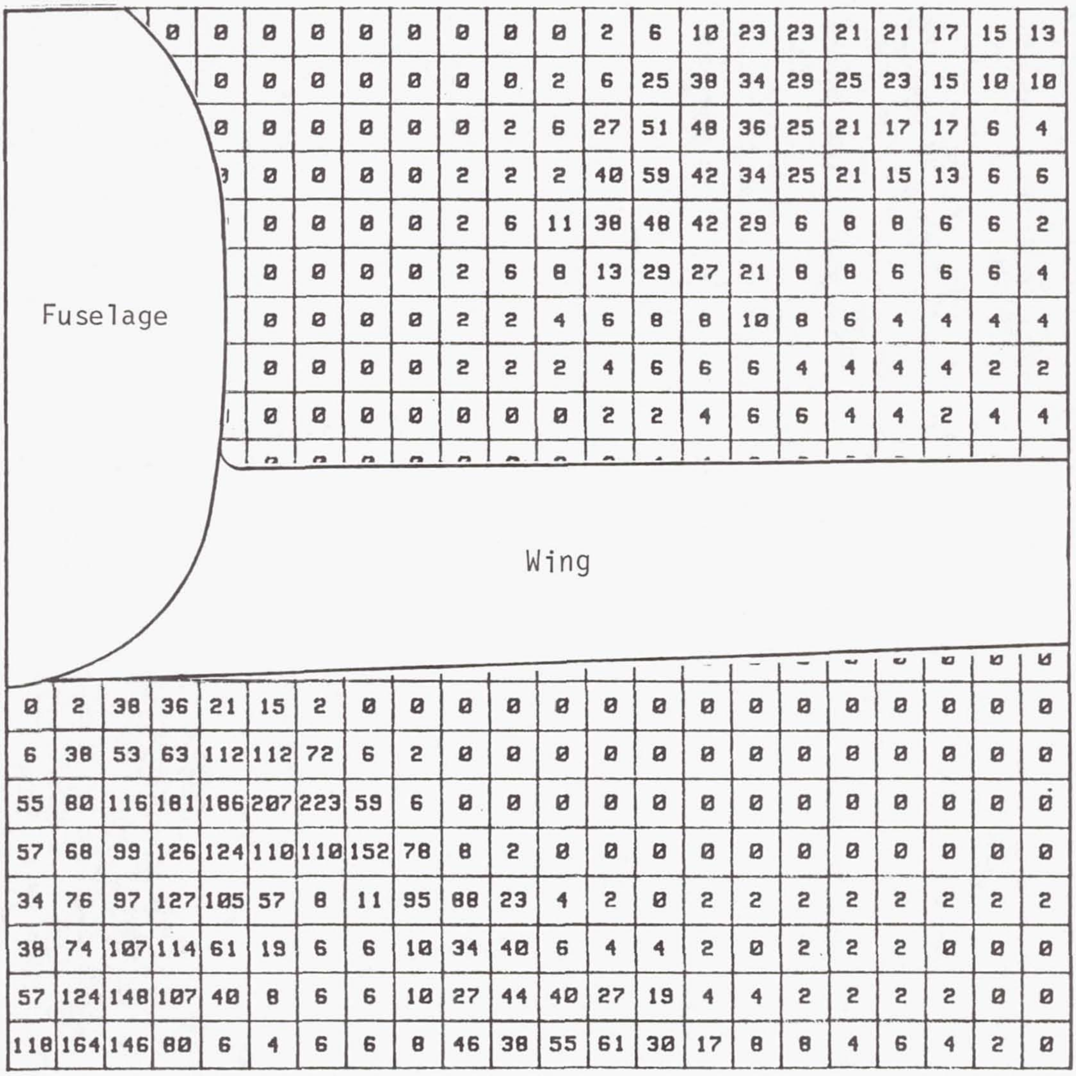
Fuselage profile

			0	0	0	0	0	0	0	0	0	0	2	6	11	11	11	11	11	11	11
				0	0	0	0	0	0	0	0	4	11	17	17	19	13	13	8	4	6
				0	0	0	0	0	0	0	4	19	27	21	23	21	13	6	4	4	4
				0	0	0	0	0	0	2	15	32	29	27	19	15	13	8	6	4	4
					0	0	0	0	0	10	49	36	30	29	21	15	8	6	4	4	2
					0	0	0	2	4	34	55	40	34	25	13	10	8	4	2	2	2
					0	0	0	2	17	57	49	36	25	15	8	4	4	2	2	2	2
					0	0	2	6	46	68	46	27	21	11	8	8	4	4	4	4	4
					0	0	4	19	82	59	34	11	11	10	10	6	4	4	2	2	2
				0	0	0	6	57	68	44	19	10	8	6	6	6	4	4	2	2	0
				0	0	0	46	82	63	23	10	10	6	4	2	2	2	2	2	2	0
				0	2	40	91	70	34	13	6	6	2	2	2	2	2	2	0	0	0
			0	0	27	76	76	42	19	6	4	4	2	2	0	2	0	0	0	0	0
		0	0	11	70	74	53	32	6	2	2	0	2	2	2	2	0	0	0	0	0
0	0	0	15	72	76	63	46	10	0	0	0	2	0	2	0	2	0	2	0	0	0
0	4	27	53	61	63	48	19	4	2	0	0	2	0	2	0	0	0	0	0	0	0
6	4	32	42	63	48	36	17	4	2	0	0	0	0	0	0	0	0	0	0	0	0
11	19	32	53	70	59	21	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0
11	21	42	76	76	42	17	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0
17	38	80	91	61	30	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	67	89	86	76	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	122	114	76	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps Load = 2500 lb Water depth = .625 in. Tire pressure = 35 psi
Coordinates: x = 199 in. y = 14 in. z = 16 in.
Flow values are in gallons per minute $\times 10^2$

(a) Fuselage only.

Figure 21. Effect of wing in aft position on spray pattern.



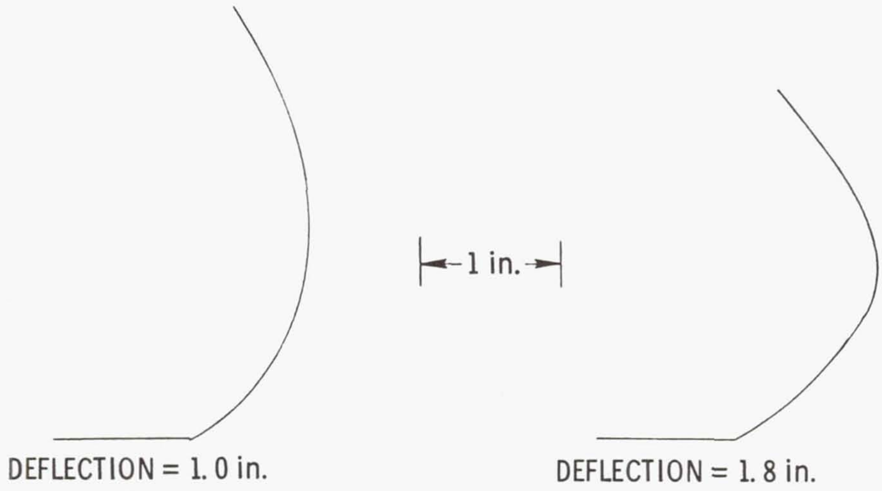
Speed = 60 fps Load = 2500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = 14 in. z = 16 in.

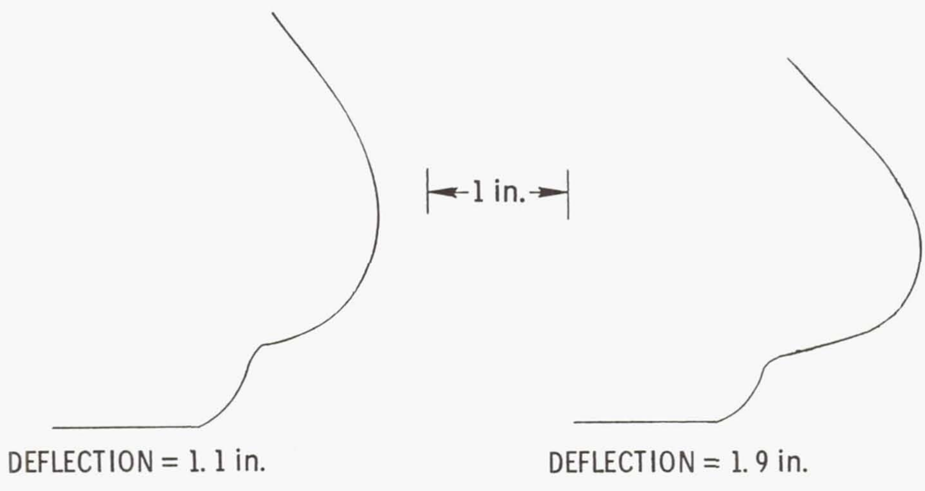
Flow values are in gallons per minute $\times 10^2$

(b) Fuselage with wing in aft position.

Figure 21. Concluded.



(a) 26 × 6.6, 12-ply rating, type VII bias-ply tire.



(b) 26 × 6.6, R14, 12-ply rating radial tire.

Figure 22. Sidewall profiles of nose tires on commercial transport aircraft. (Inflation pressure = 45 psi.)

0	0	2	2	4	4	6	10	13	15	21	30	36	55	44	40	40	21	23	13	8	4
0	2	2	2	4	6	8	8	13	19	29	44	49	61	59	48	36	34	19	21	2	2
2	2	4	6	8	8	13	15	21	34	46	48	57	61	40	27	19	11	6	4	2	2
2	2	2	2	2	6	8	8	17	23	30	38	51	57	51	38	23	17	11	6	4	2
4	4	4	6	8	8	10	15	19	21	30	38	42	42	34	25	19	10	11	6	4	0
4	6	6	6	6	6	13	13	17	23	30	36	36	36	27	21	15	8	6	4	4	0
6	6	6	8	8	13	15	19	21	25	34	34	36	30	19	15	11	10	6	6	4	0
6	6	6	6	8	10	15	21	29	29	38	34	32	23	19	13	8	8	4	0	2	0
6	6	6	6	8	11	17	23	30	34	38	34	23	19	10	6	6	6	4	0	2	0
6	6	6	10	15	19	32	32	34	38	32	21	38	6	6	4	4	4	2	2	2	2
4	4	6	10	10	17	21	30	38	38	30	29	17	10	8	8	4	4	2	2	0	0
2	2	6	8	13	21	32	36	30	34	21	19	15	8	8	6	6	4	4	4	4	2
2	6	6	13	17	29	30	40	38	36	19	15	6	4	4	4	2	2	2	2	2	2
2	4	6	15	27	38	42	48	40	25	17	10	2	2	2	0	0	0	0	0	0	0
2	4	10	17	38	38	46	44	34	13	10	4	4	2	0	2	2	2	2	2	0	0
4	11	23	34	40	55	55	48	32	13	4	2	0	0	0	0	2	2	0	0	2	0
2	10	8	38	57	59	46	29	13	8	2	2	0	0	2	2	2	0	0	2	0	0
6	6	38	49	63	53	38	19	6	4	0	2	0	0	0	0	0	2	2	0	0	0
10	25	53	65	74	57	21	6	4	0	0	0	2	0	0	0	0	2	0	0	0	0
15	36	57	82	72	34	17	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0
21	57	86	95	51	25	8	2	2	2	0	0	0	2	0	0	0	0	0	0	0	0
38	76	110	84	42	4	2	2	0	0	0	0	0	2	0	0	2	0	0	0	0	0

Speed = 60 fps   Tire deflection = 1.8 in.   Water depth = .625 in.

Tire pressure = 45 psi   Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

(a) Bias-ply tire.

Figure 23. Comparison of water-spray patterns for 26×6.6, tubeless, bias-ply and radial aircraft tires measured 199 in. aft of tire.

0	0	0	0	0	0	0	2	2	6	10	10	17	19	23	19	19	17	13	6	2	0
0	0	0	0	0	0	0	2	4	8	10	15	19	19	27	25	23	15	10	4	4	0
0	0	0	0	0	0	0	2	4	6	10	19	19	36	38	21	19	15	13	8	6	0
0	0	0	0	0	0	0	2	6	11	15	25	38	38	30	19	21	19	10	6	2	0
0	0	0	0	0	0	2	4	6	15	27	34	36	36	29	19	17	13	8	6	2	0
0	0	0	0	0	0	2	4	10	19	27	34	44	38	23	19	17	8	6	4	2	0
0	0	0	0	0	0	2	4	11	17	32	51	57	36	19	19	15	13	8	4	0	0
0	0	0	0	0	0	2	8	11	23	38	42	53	36	17	6	6	6	2	4	0	0
0	0	0	0	0	2	4	8	13	23	40	48	48	36	2	6	6	6	2	2	0	0
0	0	0	0	0	0	2	8	19	29	48	55	38	17	6	4	2	2	0	0	0	0
0	0	0	0	0	2	4	8	11	32	40	53	34	23	13	6	4	2	2	0	0	0
0	0	0	0	0	2	4	11	19	44	48	36	21	17	10	2	2	0	0	0	0	0
0	0	0	0	0	2	4	19	29	40	48	32	19	11	6	4	0	0	0	0	0	0
0	0	0	0	0	4	15	21	44	38	44	25	17	15	2	2	0	0	0	0	0	0
0	0	0	0	2	6	19	38	49	42	38	19	8	6	4	0	0	0	0	0	0	0
0	0	0	0	4	8	29	36	46	34	23	10	6	2	0	0	0	0	0	0	0	0
0	0	0	2	11	19	51	59	80	25	17	6	2	0	0	0	0	0	0	0	0	0
0	0	0	2	21	44	63	76	34	13	8	2	2	0	0	0	0	0	0	0	0	0
0	0	4	8	30	101	76	40	8	4	0	0	0	0	0	0	0	0	0	0	0	0
2	6	8	34	84	110	70	23	4	0	0	0	0	0	0	0	0	0	0	0	0	0
2	6	17	74	120	91	29	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0
2	10	42	116	105	44	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0

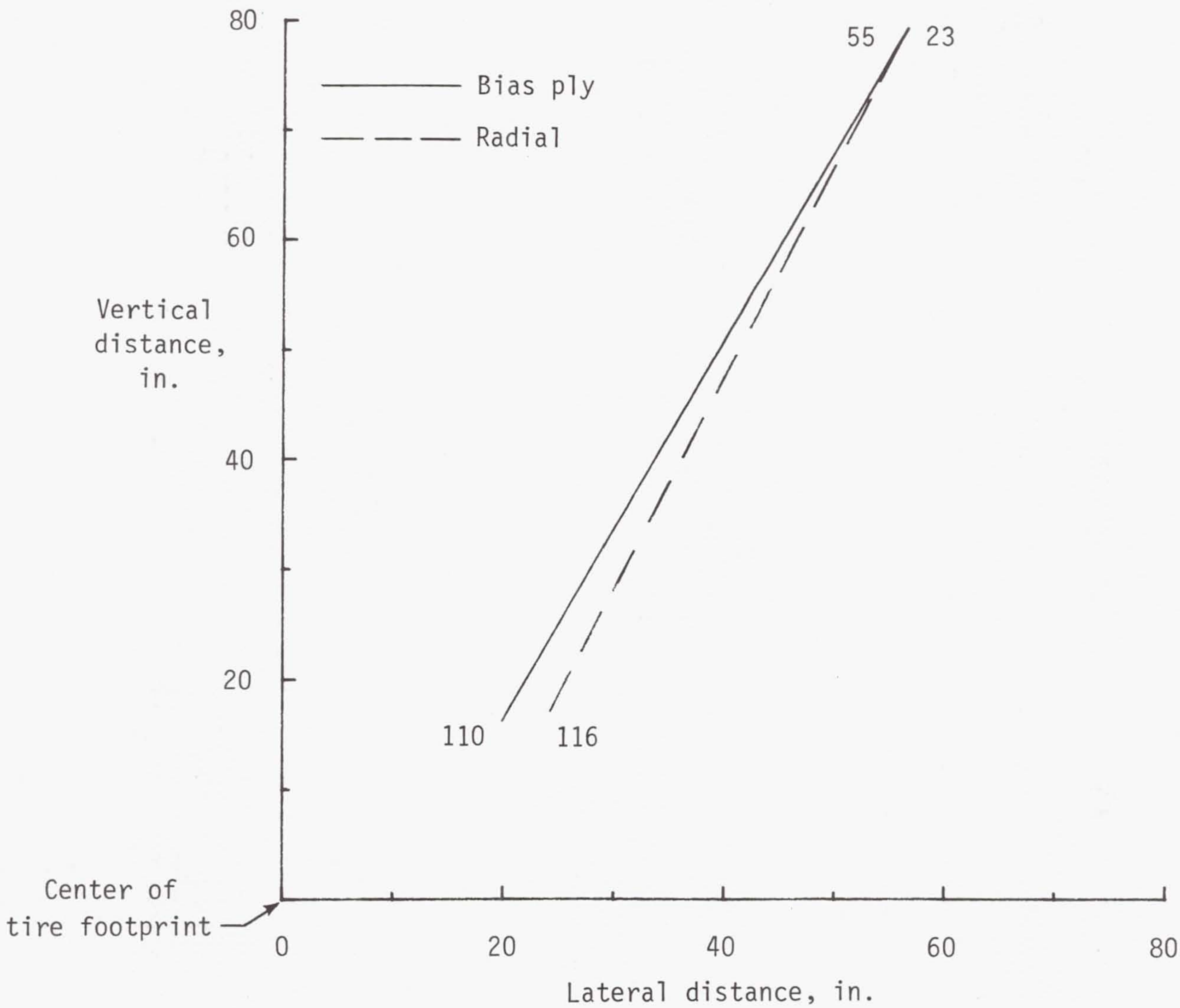
Speed = 60 fps   Tire deflection = 1.9 in.   Water depth = .625 in.

Tire pressure = 45 psi   Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

(b) Radial tire.

Figure 23. Continued



(c) Comparison of water-spray flow concentration.

Figure 23. Concluded.

Run 1

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	3	1	4	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	4	5	5	5	3	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	8	8	8	8	6	8	10	10	11	10	9	6	0	0	0	0	0	0	0	0	0
1	8	8	9	10	10	11	11	11	11	10	9	5	0	0	0	0	0	0	0	0	0
4	6	9	13	13	11	10	11	11	9	8	4	3	0	0	0	0	0	0	0	0	0
8	10	14	13	11		10	11	10	8		4	3	0	0	0	0	0	0	0	0	0
					9	10	10	8	4	3	1	1	0	0	0	0	0	0	0	0	0
					9	10	8	4	3	1	1	1	0	0	0	0	0	0	0	0	0
					8	6	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0
					3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 40 fps   Load = 500 lb   Water depth = .500 in.   Tire pressure = 35 psi

Coordinates: x = 31 in.   y = 26.5 in.   z = 15.5 in.

Flow values are in gallons per minute × 10^2

Figure A1. Tire-only test configuration with 6.00 × 6 bias-ply tire.

Run 2

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	6	2	0	0	2	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	6	0	2	6	8	13	13	13	11	13	4	4	0	0	0	0	0	0	0	0	0
2	4	4	0	11	13	17	21	23	19	15	8	2	0	0	0	0	0	0	0	0	0
6	6	13	17	17	19	23	21	23	15	11	6	2	0	0	0	0	0	0	0	0	0
10	21	27	23	23	15	19	19	15	11	10	2	2	0	0	0	0	0	0	0	0	0
					17	17	15	11	8	2	0	2	0	0	0	0	0	0	0	0	0
					13	13	11	4	4	2	0	0	0	0	0	0	0	0	0	0	0
					4	2	4	0	2	0	2	2	0	0	0	0	0	0	0	0	0
					4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 500 lb   Water depth = .500 in.   Tire pressure = 35 psi

Coordinates: x = 31 in.   y = 26.5 in.   z = 15.5 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 3

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	3	3	3	3	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3	3	3	5	5	8	8	0	0	0	0	0	0	0	0	0
3	3	3	5	0	8	5	8	0	10	10	10	10	0	0	0	0	0	0	0	0	0
3	15	15	10	5	23	20	20	18	15	15	18	18	0	0	0	0	0	0	0	0	0
					28	25	20	18	15	18	18	10	0	0	0	0	0	0	0	0	0
					23	20	18	15	13	13	18	5	0	0	0	0	0	0	0	0	0
					18	13	18	10	10	10	8	5	0	0	0	0	0	0	0	0	0
					10	5	8	8	0	8	8	0	0	0	0	0	0	0	0	0	0

Speed = 80 fps Load = 500 lb Water depth = .500 in. Tire pressure = 35 psi

Coordinates: x = 31 in. y = 26.5 in. z = 15.5 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

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Run 4

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	1	3	3	3	3	4	4	0	0	0	0	0	0	0
0	0	0	0	0	0	0	3	3	4	4	4	9	6	6	0	0	0	0	0	0	0
0	0	0	0	0	0	0	4	5	5	6	8	10	10	9	0	0	0	0	0	0	0
0	0	0	0	0	0	0	5	5	8	9	10	10	10	10	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	8	10	11	11	11	10	9	0	0	0	0	0	0	0
1	1	0	1	3	4	4	9	11	10	11	11	11	10	9	0	0	0	0	0	0	0
3	4	5	5	8	8	8	11	10	10	10	11	10	9	5	0	0	0	0	0	0	0
6	6	9	10	11	10	5	6	6	9	10	10	10	5	3	0	0	0	0	0	0	0
	9	13	16	14	9	6	4	5	5	5	3	3	1	1	0	0	0	0	0	0	0
6	14	19	15	9	8	4	4	4	5	4	4	3	1	1	0	0	0	0	0	0	0
10	18	15	8	6	4	4	3	4	4	4	3	1	1	0	0	0	0	0	0	0	0
18	14	10	6	4	3	3	3	3	3	3	1	1	0	0	0	0	0	0	0	0	0
11	6	5	5	3	1	1	3	1	1	1	1	0	0	0	0	0	0	0	0	0	0

Speed = 40 fps   Load = 2500 lb   Water depth = .500 in.   Tire pressure = 35 psi

Coordinates: x = 31 in.   y = 26.5 in.   z = 27.5 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 5

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	2	6	6	6	6	6	6	6	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	8	10	13	15	17	19	13	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	8	10	8	19	21	17	13	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	10	15	13	19	13	13	11	0	0	0	0	0	0	0
0	0	0	0	0	0	0	8	10	10	15	21	19	15	11	0	0	0	0	0	0	0
0	0	2	2	4	4	4	13	17	17	17	17	11	2	0	0	0	0	0	0	0	0
0	2	4	4	4	4	4	15	17	17	17	13	2	2	0	0	0	0	0	0	0	0
2	2	4	4	4	4	6	13	15	15	13	11	2	0	0	0	0	0	0	0	0	0
8	10	10	13	15	10	10	10	13	15	13	4	2	0	0	0	0	0	0	0	0	0
8	15	25	27	17	11	11	11	15	13	6	4	2	0	0	0	0	0	0	0	0	0
17	36	34	25	17	13	6	10	10	10	4	2	0	0	0	0	0	0	0	0	0	0
36	30	23	17	15	11	8	6	4	2	2	0	0	0	0	0	0	0	0	0	0	0
27	17	17	13	8	6	6	4	2	2	2	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 2500 lb   Water depth = .500 in.   Tire pressure = 35 psi

Coordinates: x = 31 in.   y = 26.5 in.   z = 27.5 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 6

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	3	5	5	8	10	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	3	3	8	8	8	18	20	0	0	0	0	0	0	0
0	0	0	0	0	0	0	3	5	5	8	13	20	23	23	0	0	0	0	0	0	0
0	0	0	0	0	0	0	3	8	8	13	20	23	28	23	0	0	0	0	0	0	0
0	0	0	0	0	0	0	5	8	10	18	23	23	25	10	0	0	0	0	0	0	0
0	0	0	3	5	8	8	8	13	15	23	25	25	18	10	0	0	0	0	0	0	0
0	0	3	5	5	8	8	8	18	23	25	25	20	13	5	0	0	0	0	0	0	0
3	3	5	5	8	8	8	15	23	25	25	23	18	10	3	0	0	0	0	0	0	0
0	8	8	5	8	8	13	10	23	23	20	18	8	3	0	0	0	0	0	0	0	0
10	13	20	18	20	18	18	20	20	20	15	10	3	0	0	0	0	0	0	0	0	0
25	53	46	30	25	20	18	18	18	13	8	3	0	0	0	0	0	0	0	0	0	0
63	53	41	33	25	20	15	18	15	10	3	3	0	0	0	0	0	0	0	0	0	0
36	28	30	25	18	10	10	13	5	5	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 80 fps Load = 2500 lb Water depth = .500 in. Tire pressure = 35 psi

Coordinates: x = 31 in. y = 26.5 in. z = 27.5 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 7

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	4	4	3	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	4	6	6	6	6	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	6	8	9	9	10	11	13	13	11	10	8	3	0	0	0	0	0	0	0	0	0
3	5	8	10	10	10	11	10	11	10	8	5	3	0	0	0	0	0	0	0	0	0
6	9	10	11	11	11	11	11	10	9	5	4	1	0	0	0	0	0	0	0	0	0
5	3	16	15	11	11	11	11	10	5	3	3	0	0	0	0	0	0	0	0	0	0
					11	14	11	6	4	1	0	0	0	0	0	0	0	0	0	0	0
					10	11	9	5	1	0	0	0	0	0	0	0	0	0	0	0	0
					8	6	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0
					3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 40 fps   Load = 500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 31 in.   y = 26.5 in.   z = 15.5 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 8

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	2	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	2	2	4	6	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	2	0	2	6	15	15	21	23	23	21	13	4	0	0	0	0	0	0	0	0	0
4		6	10	13	23	25	25	27	21	15	8	0	0	0	0	0	0	0	0	0	0
6	8	17	19	17	23	21	19	19	11	4	2	0	0	0	0	0	0	0	0	0	0
15	30	40	30	25	4	17	13	10	4	2	0	0	0	0	0	0	0	0	0	0	0
					10	11	11	4	2	0	0	0	0	0	0	0	0	0	0	0	0
					8	6	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0
					6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 31 in.   y = 26.5 in.   z = 15.5 in.

Flow values are in gallons per minute × 10^2

Figure A1. Continued.

Run 9

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	3	3	0	3	3	5	5	8	0	0	0	0	0	0	0	0	0
0	0	0	0	3	8	8	10	10	13	13	18	20	0	0	0	0	0	0	0	0	0
0	0	5	5	5	25	23	20	20	20	18	18	18	0	0	0	0	0	0	0	0	0
5	23	28	25	13	25	28	23	18	13	13	13	13	0	0	0	0	0	0	0	0	0
					30	23	18	18	15	13	10	10	0	0	0	0	0	0	0	0	0
					18	18	15	10	10	10	10	8	0	0	0	0	0	0	0	0	0
					10	10	8	8	8	8	8	5	0	0	0	0	0	0	0	0	0
					5	5	5	5	5	5	5	3	0	0	0	0	0	0	0	0	0

Speed = 80 fps   Load = 500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 31 in.   y = 26.5 in.   z = 15.5 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 10

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	3	4	5	6	8	9	11	11	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	8	6	8	10	11	11	11	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	8	6	9	10	11	10	4	0	0	0	0	0	0	0
0	0	0	0	0	0	0	5	8	9	10	11	13	13	11	0	0	0	0	0	0	0
0	0	0	0	0	0	0	9	10	11	11	13	13	10	6	0	0	0	0	0	0	0
3	1	0	3	4	4	4	11	10	10	11	13	13	9	6	0	0	0	0	0	0	0
6	4	4	6	10	10	9	11	10	10	13	11	10	5	4	0	0	0	0	0	0	0
8	6	9	13	14	10	8	6	8	10	11	11	9	5	3	0	0	0	0	0	0	0
0	10	15	18	13	8	5	1	5	6	4	3	1	1	1	0	0	0	0	0	0	0
10	16	20	13	9	4	4	4	4	4	3	1	1	1	0	0	0	0	0	0	0	0
16	20	11	10	5	4	4	3	4	3	1	1	1	0	0	0	0	0	0	0	0	0
13		6	4	3	3	3	3	1	1	1	0	0	1	0	0	0	0	0	0	0	0
8	5	5	3	1	1	3	3	1	1	1	0	1	0	1	0	0	0	0	0	0	0

Speed = 40 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 31 in.   y = 26.5 in.   z = 27.5 in.

Flow values are in gallons per minute $\times 10^2$

Figure A1. Continued.

Run 11

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	4	8	11	13	15	17	17	10	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	11	13	15	19	19	17	8	0	0	0	0	0	0	0
0	0	0	0	0	0	0	4	8	11	19	23	19	13	6	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	10	15	21	25	19	11	2	0	0	0	0	0	0	0
0	0	0	0	0	0	0	10	15	21	27	23	13	6	0	0	0	0	0	0	0	0
0	0	2	4	4	4	4	15	19	23	23	17	11	2	0	0	0	0	0	0	0	0
4	4	4	6	6	8	8	17	19	25	19	11	6	2	0	0	0	0	0	0	0	0
8	10	11	13	17	15	11	13	17	19	15	8	2	0	0	0	0	0	0	0	0	0
4	13	21	25	19	15	13	10	11	10	10	2	0	0	0	0	0	0	0	0	0	0
13	27	32	23	15	13	10	13	13	8	6	2	0	0	0	0	0	0	0	0	0	0
25	34	23	15	11	10	8	11	10	6	4	0	0	0	0	0	0	0	0	0	0	0
32	19	15	11	8	6	6	6	4	4	2	0	0	0	0	0	0	0	0	0	0	0
17	13	8	6	6	4	6	4	2	0	0	2	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 31 in.   y = 26.5 in.   z = 27.5 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 12

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	3	5	5	8	20	25	28	0	0	0	0	0	0	0
0	0	0	0	0	0	0	3	8	13	18	20	23	30	30	0	0	0	0	0	0	0
0	0	0	0	0	0	0	5	10	15	18	20	25	33	25	0	0	0	0	0	0	0
0	0	0	0	0	0	0	5	10	13	15	18	28	33	23	0	0	0	0	0	0	0
0	0	0	0	0	0	0	8	10	10	13	20	30	25	13	0	0	0	0	0	0	0
0	3	0	0	5	5	5	5	8	10	15	25	25	18	3	0	0	0	0	0	0	0
3	3	5	8	8	8	8	8	10	13	23	25	20	5	0	0	0	0	0	0	0	0
8	8	8	8	8	8	8	10	15	20	23	18	10	0	0	0	0	0	0	0	0	0
0	10	10	15	15	15	15	23	23	20	18	10	8	0	0	0	0	0	0	0	0	0
15	28	41	30	23	23	20	18	18	20	18	5	3	0	0	0	0	0	0	0	0	0
51	46	48	36	25	23	15	13	15	15	5	3	0	0	0	0	0	0	0	0	0	0
58	43	38	30	25	20	13	8	8	5	3	3	0	0	0	0	0	0	0	0	0	0
28	28	28	23	18	13	10	8	8	5	3	0	0	0	0	0	0	0	0	0	0	0

Speed = 80 fps Load = 2500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 31 in. y = 26.5 in. z = 27.5 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 13

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	1	1	3	3	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	3	1	3	3	4	4	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	1	5	8	6	6	9	9	0	0	0	0	0	0	0	0
0	0	0	0	0	1	3	3	10	10	13	13	0	5	0	0	0	0	0	0	0	0
0	0	0	0	4	5	6	10	18	11	13	13	13	9	0	0	0	0	0	0	0	0
0	0	0	0	5	11	1	3	18	9	11	11	11	13	0	0	0	0	0	0	0	0
0	0	3	10	18	18	15	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	6	28	32	19	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 40 fps Load = 500 lb Water depth = .500 in. Tire pressure = 35 psi

Coordinates: x = 76 in. y = 13 in. z = 26 in.

Flow values are in gallons per minute $\times 10^2$

Figure A1. Continued.

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Run 14

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	2	2	4	4	4	6	6	6	0	0	0	0	0	0	0	0
0	0	0	0	0	0	2	6	6	11	15	15	15	15	0	0	0	0	0	0	0	0
0	0	0	0	0	2	10	15	17	21	21	21	19	17	0	0	0	0	0	0	0	0
0	0	0	2	4	6	17	27	25	23	19	19	10	17	0	0	0	0	0	0	0	0
0	0	2	4	6	15	40	30	23	21	19	19	17	17	8	6	6	6	6	0	0	0
0	2	6	8	21	42	27	19	19	19	17	13	13	10	6	6	6	6	6	0	0	0
0	4	8	23	40	64	30	15				6	4	4	2	4	4	6	6	0	0	0
4	6	17	51	120	44	23	19				2	2	2	2	2	2	2	2	0	0	0

Speed = 60 fps   Load = 500 lb   Water depth = .500 in.   Tire pressure = 35 psi

Coordinates: x = 76 in.   y = 13 in.   z = 26 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 15

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	5	5	3	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	3	5	3	8	8	8	0	0	0	0	0	0	0	0
0	0	0	0	0	5	5	8	10	10	13	13	10	10	0	0	0	0	0	0	0	0
0	0	0	3	8	8	15	28	30	33	25	30		23	0	0	0	0	0	0	0	0
0	3	3	3	8	13	58	74	48	33	28	30	28	25	25	20	20	18	0	0	0	0
0	0	3	0	23	36	81	41	36	30	25	25	25	25	23	20	18	15	0	0	0	0
3	0	3	10	38	117	167	81			18	23	20	18	18	18	18	15	0	0	0	0
0	3	8	15	66	299	155	41				10	10	8	8	8	8	8	0	0	0	0

Speed = 80 fps Load = 500 lb Water depth = .500 in. Tire pressure = 35 psi

Coordinates: x = 76 in. y = 13 in. z = 26 in.

Flow values are in gallons per minute $\times 10^2$

Figure A1. Continued.

Run 16

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	4	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	0	1	3	3	5	5	6	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	3	4	6	9	13	11	10	0	0	0
0	0	0	0	0	0	0	0	0	0	0	4	4	11	15	14	11	11	10	0	0	0
0	0	0	0	0	0	0	0	0	0	0	11	16	13	3	11	10	10	8	0	0	0
0	0	0	0	0	0	1	3	4	9	11	13	18	18	9	9	10	9	6	0	0	0
0	0	0	0	0	0	6	9	14	14	10	9	9	10	10	11	8	6	5	0	0	0
0	0	1	1	3	4	10	15	14	10	10	8	8	9	0	0	0	0	0	0	0	0
0	1	3	3	4	5	18	16	13	9	8	4	5	6	0	0	0	0	0	0	0	0
0	1	3	4	6	10	15	11	9	8	6	6	5	5	0	0	0	0	0	0	0	0
0	3	4	4	9	13	13	8	6	4	4	4	0	3	0	0	0	0	0	0	0	0
1	3	5	9	15	27	10	4	4	4	4	4	4	4	0	0	0	0	0	0	0	0
3	4	8		30	28	5	4	4	3	1	1	3	3	0	0	0	0	0	0	0	0
1	3	13	28	46	23	9	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	5	19	55	48	14	10	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 40 fps   Load = 2500 lb   Water depth = .500 in.   Tire pressure = 35 psi

Coordinates: x = 76 in.   y = 13 in.   z = 26 in.

Flow values are in gallons per minute $\times 10^2$

Figure A1. Continued.

Run 17

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	4	6	2	0	0	0
0	0	0	0	0	0	0	0	0	0	0	2	4	6	6	8	6	10	8	0	0	0
0	0	0	0	0	0	0	0	0	0	0	4	4	6	6	10	11	13	13	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	4	6	10	17	15	15	15	0	0	0
0	0	0	0	0	0	0	0	0	0	0	4	11	13	19	17	13	15	13	0	0	0
0	0	0	0	0	0	0	0	0	0	0	21	25	21	19	13	15	13	8	0	0	0
0	0	0	0	0	0	4	8	10	19	25	27	21	19	17	17	15	11	11	0	0	0
0	0	0	0	0	0	6	19	30	30	25	21	15	17	13	11	8	10	10	0	0	0
0	4	4	2	4	6	23	34	36	23	17	15	13	11	0	0	0	0	0	0	0	0
4	4	4	8	8	13	29	36	27	17	11	15	13	10	0	0	0	0	0	0	0	0
4	4	8	11	13	21	40	23	17	13	11	10	10	10	0	0	0	0	0	0	0	0
0	2	6	13	21	30	27	17	13	8	8	6	6	0	0	0	0	0	0	0	0	0
4	8	10	19	32	59	15	11	8	8	6	6	6	2	0	0	0	0	0	0	0	0
4	6	15	21	51	72	17	8	6	4	2	0	4	4	0	0	0	0	0	0	0	0
8	11	21	49	101	48	17	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	13	36	97	100	34	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 2500 lb   Water depth = .500 in.   Tire pressure = 35 psi

Coordinates: x = 76 in.   y = 13 in.   z = 26 in.

Flow values are in gallons per minute × 10^2

Figure A1. Continued.

Run 18

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	5	5	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	3	3	5	8	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	5	3	0	0	0	5	8	0	0	0
0	0	0	0	0	0	0	0	0	0	0	3	3	5	5	8	0	8	10	0	0	0
0	0	0	0	0	0	0	0	0	0	0	10	0	10	0	15	13	10	0	0	0	0
0	0	0	0	0	0	5	8	20	33	41	28	28	25	20	13	13	15	3	0	0	0
0	0	0	0	0	0	18	38	58	53	41	36	13	25	23	20		15	18	0	0	0
0	5	0	3	5	10	51	61	58	41	38	30	25	20	0	0	0	0	0	0	0	0
5	3	5	10	13	20	33	51	33	36	25	23	20	18	0	0	0	0	0	0	0	0
3	5	0	8	13	25	58	43	28	23	25	23	18	18	0	0	0	0	0	0	0	0
0	5	10	15	20	8	51	25	23	20	18	18	15	0	0	0	0	0	0	0	0	0
8	8	10	18	30		28	23	20	18	13	13	13	13	0	0	0	0	0	0	0	0
5	13	18		48	101	25	10	13	8	10	8	10	10	0	0	0	0	0	0	0	0
5	10	23	43	81	127	41	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	10	30	74	152	88	33	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 80 fps   Load = 2500 lb   Water depth = .500 in.   Tire pressure = 35 psi

Coordinates: x = 76 in.   y = 13 in.   z = 26 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 19

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	1	3	3	3	3	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	1	3	3	4	5	6	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	1	3	5	8	9	10	9	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3	0	6	10	16	11	25	25	0	0	0	0	0	0	0	0
0	0	0	0	0	0	18	10	9	20	25	27	24	24	0	0	0	0	0	0	0	0
1	3	3	4	3	6	8	16	18	19	18	19	16	18	0	0	0	0	0	0	0	0
0	1	1	3	4	5	8	10	22	20	14	13	11	11	0	0	0	0	0	0	0	0
1	0	0	4	6	16	24	27	16	15	8	8	8	8	0	0	0	0	0	0	0	0
0	4	5	8	9		16	23	11	6	6	5	5	4	0	0	0	0	0	0	0	0
4	5	0	6	20	37	25	19	1	4	3	4	3	4	0	0	0	0	0	0	0	0
5	6	8	25	41	37	8	8	4	3	3	3	0	4	0	0	0	0	0	0	0	0
6	11	13	37	53	23	8	4	3	3	5	3	3	4	0	0	0	0	0	0	0	0
8	18	38	65	42	13	0	1	41	29	18	13	25	4	0	0	0	0	0	0	0	0
10	29	61	110	29	4	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	37	110	129	15	3	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 40 fps   Load = 500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 76 in. · y = 13 in.   z = 26 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 20

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	2	2	2	0	2	4	6	6	0	0	0	0	0	0	0	0
0	0	0	0	0	0	6	6	8	8	10	15	19	19	0	0	0	0	0	0	0	0
8	10	13	23	34	44	10	10	11	21	27	27	25	25	0	0	0	0	0	0	0	0
10	13	23	29	42	55		29	34	34	29	25	23	27	0	0	0	0	0	0	0	0
13	21	27	42	65	67	38	48	36	29	23	19	23	23	0	0	0	0	0	0	0	0
13	27	38	61	97	61	51	36	23	15	17	19		6	0	0	0	0	0	0	0	0
23	25	53	97	105	30	32	15	15	11	18	10	18	18	0	0	0	0	0	0	0	0
21	42	93	164	86	21	15	8	8	8	8	8	6	4	0	0	0	0	0	0	0	0
27	49	146	257	65	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	61	272	365	25	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 76 in.   y = 13 in.   z = 26 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 21

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	3	0	3	3	3	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	3	5	5	5	8	0	0	0	0	0	0	0	0
0	8	18	33	68	117	139	94	8	13	13	10	10	15	0	0	0	0	0	0	0	0
8	13	25	46	104	165	134	58	18	25	23	25	25	25	0	0	0	0	0	0	0	0
8	13	28	53	172	208	107	38	36	30	28	30	30	33	0	0	0	0	0	0	0	0
8	10	25	79	312	145	63	74	51	28	33	28	13	8	0	0	0	0	0	0	0	0
8	8	30	127	424	172	99	71	46	36	28	10	18	23	23	20	23	20	18	0	0	0
8	10	33	276	571	84	107	48	33	28	25	8	10	10	10	15	15	15	15	0	0	0
8	13	51	748		71						0	0	0	0	0	0	0	0	0	0	0
5	13	101	1268	198	13						0	0	0	0	0	0	0	0	0	0	0

Speed = 80 fps   Load = 500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 78 in.   y = 13 in.   z = 26 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

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OF POOR QUALITY

Run 22

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3	3	3	4	8	10	20	20	0	0	0	0	0	0	0	0
0	0	0	0	0	0	4	3	5	8	16	22	23	18	0	0	0	0	0	0	0	0
0	0	0	0	0	0	4	4	8	16	11	23	15	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	8	4	20	24	20	8	8	5	0	0	0	0	0	0	0	0
0	0	0	0	0	0	10	19	27	25	19	10	4	4	0	0	0	0	0	0	0	0
3	3	4	4	6	9	22	29	28	20	9	5	0	1	0	0	0	0	0	0	0	0
4	3	4	6	9	18	32	38	27	15	13	5	5	3	0	0	0	0	0	0	0	0
4	1	4	9	19	27	36	30	25	16	9	5	0	3	0	0	0	0	0	0	0	0
3	5	8	11	19	4	44	19	8	4	1	0	0	1	0	0	0	0	0	0	0	0
4	6	6	27	39	51	36	10	4	3	3	1	1	1	0	0	0	0	0	0	0	0
6	10	23	39	56	79	19	5	4	3	1	1	0	1	0	0	0	0	0	0	0	0
4	16	29	0	74	34	13	4	3	0	1	0	1	1	0	0	0	0	0	0	0	0
8	19	47	70	94	20	8	22	27	27	9	1	1	1	0	0	0	0	0	0	0	0
8	23	67	150	72	6	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	33	100	203	34	5	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 40 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 76 in.   y = 13 in.   z = 26 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 23

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	2	4	6	6	8	13	13	19	0	0	0
0	0	0	0	0	0	0	0	0	0	0	2	4	8	11	15	13	21	19	0	0	0
0	0	0	0	0	0	0	0	0	0	0	6		6	23	21	23	19	17	0	0	0
0	0	0	0	0	0	0	0	0	0	0		23	25	27	4	8	15	15	0	0	0
0	0	0	0	0	0	0	0	0	0	0	27	30	27	23	19	10	13	13	0	0	0
0	0	0	0	0	0	0	0	0	0	0	30	25	21	17	13	11	8	0	0	0	0
0	0	0	0	0	0	8	11	25	32	27	23	19	17	13	11	8	8	6	0	0	0
0	0	0	0	0	0	10	34	36	30	23	15	15	11	10	8	8	6	8	0	0	0
0	11	15	21	34	48	42	38	27	23	19	15	11	8	0	0	0	0	0	0	0	0
6	13	17	30	46	65	27	30	21	17	11	8	8	6	0	0	0	0	0	0	0	0
6	13	25	42	65	82	30	21	13	11	8	6	6	6	0	0	0	0	0	0	0	0
11	19	34	67	91	80	27	15	6	0	4	6	0	0	0	0	0	0	0	0	0	0
11	21	42	91	131	89	15	4	4	4	6	4	4	0	0	0	0	0	0	0	0	0
8	29	61	114	173	68	6	2	4	6	4	4	4	4	0	0	0	0	0	0	0	0
10	32	80	171	223	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	32	114	255	249	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 76 in.   y = 13 in.   z = 26 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 24

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	3	5	8	8	8	8	13	0	0	0
0	0	0	0	0	0	0	0	0	0	0	3	8	8	10	10	10	15	18	0	0	0
0	0	0	0	0	0	0	0	0	0	0	8	5	0	10	15	18	18	20	0	0	0
0	0	0	0	0	0	0	0	0	0	0	5	8	18	18	20	20	18	18	0	0	0
0	0	0	0	0	0	0	0	0	0	0	20	30	28	23	23	18	18	18	0	0	0
0	0	0	0	0	0	0	0	0	0	0	48	38	28	23	20	18	13	0	0	0	0
0	0	0	0	0	0	5	8	10	23	33	41	33	28	25	20	20	18	0	0	0	0
0	0	0	0	0	0	10	30	48	51	46	28	28	28	23	20	18	10	18	0	0	0
0	13	15	20	36	56	46	56	61	48	38	28	23	20	0	0	0	0	0	0	0	0
10	13	18	28	43	71	0	56	43	30	25	23	20	18	0	0	0	0	0	0	0	0
8	8	18	36	61	104	139	38	28	23	20	20	13	15	0	0	0	0	0	0	0	0
10	15	20	43	84	152	165	28	20	20	18	13	10	8	0	0	0	0	0	0	0	0
10	13	8	48	104	223	152	20	20	15	13	10	10	10	0	0	0	0	0	0	0	0
5	10	25	48	142	297	129	18	10	10	10	10	13	10	0	0	0	0	0	0	0	0
8	8	13	79	195	406	94	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	5	25	91	345	454	53	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 80 fps Load = 2500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 76 in. y = 13 in. z = 26 in.

Flow values are in gallons per minute × 10^2

Figure A1. Continued.

Run 25

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
0	0	0	0	3	3	0	0	0	0	0	0	1	1	1	1	1	1	0	0	1	0
0	0	0	0	3	0	0	0	0	0	0	0	0	1	3	0	1	1	1	0	3	4
0	0	0	1	0	0	0	0	0	0	0	0	3	3	1	1	1	3	1	3	3	3
0	0	0	0	0	0	0	0	0	0	0	1	1	1	4	4	3	5	5	3	1	1
0	0	0	0	0	0	0	0	0	0	1	1	1	4	4	6	6	5	4	3	3	0
0	0	0	0	0	0	0	0	0	0	1	4	4	5	11	9	4	4	3	1	0	0
0	0	0	0	0	0	0	0	0	0	3	0	4	4	9	6	6	4	1	1	3	1
0	0	0	0	0	0	0	0	0	1	3	4	10	9	15	13	5	5	1	1	0	0
0	0	0	0	0	0	0	0	1	1	4	9	11	22	20	10	8	9	1	1	0	0
0	0	0	0	0	0	0	0	0	0	10	19	25	44	16	6	4	1	0	0	0	0
0	0	0	0	0	0	0	0	0	4	6	22	43	56	30	13	6	6	6	0	0	0
0	0	0	0	0	0	0	0	0	1	13	24	55	33	28	13	10	1	0	0	0	0
0	0	0	0	0	0	0	0	1	4	20	44	67	65	28	10	0	1	0	0	0	0
0	0	0	0	0	0	4	0	4	13	33	89	70	28	33	20	5	0	0	0	0	0
0	0	0	0	0	0	0	3	6	24	89	89	32	6	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	15	58	114	42	11	4	0	0	0	0	0	0	0	0

Speed = 40 fps   Load = 500 lb   Water depth = .500 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = -1 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 26

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	4	2	2
0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	2	4	4	2	4	4
0	0	0	0	0	0	0	0	0	0	2	0	2	2	4	6	6	6	8	10	8	6
0	0	0	0	0	0	0	0	0	2	2	6	8	4	4	8	8	8	8	8	8	6
0	0	0	0	0	0	0	0	0	0	0	0	2	4	6	8	10	13	10	10	6	6
0	0	0	0	0	0	0	0	0	0	0	2	4	8	8	15	17	17	11	13	6	6
0	0	0	0	4	4	0	0	0	0	2	2	6	11	11	17	17	15	19	11	6	6
0	0	0	0	4	0	0	0	0	0	0	4	8	15	15	23	29	21	21	11	4	4
0	0	0	2	0	0	0	0	0	0	2	4	8	19	19	40	49	36	21	11	8	2
0	0	0	0	0	0	0	0	0	0	4	6	13	19	38	51	82	38	29	10	4	2
0	0	0	0	0	0	0	0	0	0	4	8	17	27	42	86	76	29	23	8	4	4
0	0	0	0	0	0	0	0	0	2	6	13	21	38	67	127	68	36	15	4	4	2
0	0	0	0	0	0	0	0	2	4	10	21	34	63	114	99	49	29	6	2	2	2
0	0	0	0	0	0	0	0	2	6	15	25	61	103	101	55	32	10	4	4	4	0
0	0	0	0	0	0	0	0	4	10	21	57	110	105	48	15	10	4	4	4	2	0
0	0	0	0	0	0	0	0	6	40	15	110	120	38	11	6	8	2	2	2	0	0
0	0	0	0	0	0	0	0	13	29	122	141	40	17	6	4	2	0	0	0	0	0
0	0	0	0	0	0	2	4	25	72	152	74	8	2	4	0	0	0	0	0	0	0
0	0	0	0	0	0	2	11	53	129	95	19	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	2	32	120	162	36	2	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	2	13	72	213	91	10	2	2	0	0	0	0	0	0	0	0	0
0	0	0	0	0	6	38	183	219	17	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps Load = 500 lb Water depth = .500 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = −1 in. z = 16 in.

Flow values are in gallons per minute × 10^2

Figure A1. Continued.

Run 27

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	8	15	20	23	10	10
0	0	0	0	0	0	0	0	0	0	0	0	3	5	8	8	20	25	38	28	23	10
0	0	0	0	0	0	0	0	0	0	0	3	3	5	10	25	25	36	38	36	23	13
0	0	0	0	0	0	0	0	0	0	0	0	5	8	8	25	36	51	48	33	23	10
0	0	0	0	0	0	0	0	0	0	3	5	8	10	20	28	43	68	71	41	33	10
0	0	0	0	0	0	0	0	0	0	3	5	8	13	23	43	76	107	91	51	25	10
0	0	0	0	0	0	0	0	0	3	3	5	8	18	25	61	114	145	147	66	25	15
0	0	0	0	0	0	0	0	3	0	3	5	8	15	25	66	139	180	150	41	25	8
0	0	0	0	0	0	0	0	0	3	3	5	18	23	48	109	185	183	76	36	13	8
0	0	0	0	0	0	0	0	3	0	5	8	25	25	61	127	160	117	41	28	8	8
0	0	0	0	0	0	0	0	0	3	5	13	36	43	86	114	107	58	18	8	3	3
0	0	0	0	0	0	0	0	3	3	5	18	58	71	117	119	71	23	8	5	3	3
0	0	0	0	0	0	0	0	3	5	10	30	68	101	89	71	28	5	5	3	3	0
0	0	0	0	0	0	0	0	3	5	25	56	109	101	68	33	15	5	3	3	0	0
0	0	0	0	0	0	0	0	0	3	10	43	101	112	71	23	15	3	0	0	0	0
0	0	0	0	0	0	0	3	5	23	94	147	81	61	25	20	20	13	5	3	3	0
0	0	0	0	0	0	0	5	13	51	160	129	61	25	15	8	0	0	0	0	0	0
0	0	0	0	0	0	3	5	30	152	178	56	25	13	5	0	0	0	0	0	0	0
0	0	0	0	0	0	3	20	112	228	96	28	10	3	0	0	0	0	0	0	0	0
0	0	0	0	0	0	8	76	261	172	25	5	3	0	0	0	0	0	0	0	0	0
0	0	0	0	0	3	36	243	304	46	5	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	15	145	439	134	25	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 80 fps   Load = 500 lb   Water depth = .500 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = -1 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 28

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	3	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	3	8	9	8
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	5	4	6	6	5
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4	5	6	4	4	8	6
0	0	0	0	0	0	0	0	0	0	0	1	3	3	5	5	6	6	8	5	5	3
0	0	0	0	0	0	0	0	0	0	0	3	3	4	6	5	5	5	4	5	3	3
0	0	0	0	0	0	0	0	0	0	3	3	4	6	6	6	6	5	5	4	3	4
0	0	0	0	0	0	0	1	1	1	3	3	5	5	8	8	8	5	4	4	4	3
0	0	0	0	0	0	1	1	3	3	4	5	5	5	18	9	4	5	3	3	3	1
0	0	0	0	0	0	0	1	1	3	4	5	8	6	13	10	9	5	4	3	3	1
0	0	0	0	0	0	1	1	3	4	9	9	13	18	9	6	6	4	1	1	1	1
0	0	0	0	0	1	0	3	3	5	6	9	14	14	14	5	5	4	1	0	0	0
0	0	0	0	0	0	0	0	3	4	6	15	19	19	15	5	4	1	0	1	1	0
0	0	0	0	0	0	0	3	5	8	13	20	22	18	16	4	3	0	0	0	0	0
0	0	0	0	0	0	0	1	3	5	9	27	34	32	5	3	1	0	0	0	0	0
0	0	0	0	0	0	0	1	4	6	15	25	32	27	14	4	1	0	0	0	0	0
0	0	0	0	0	0	1	4	6	13	23	41	29	25	13	4	0	0	0	0	0	0
0	0	0	0	0	0	1	4	10	10	25	27	57	18	3	1	0	0	0	0	0	0
0	0	0	0	0	0	0	4	8	23	33	39	41	16	4	1	0	0	0	0	0	0
0	0	0	0	0	0	0	4	5	22	44	58	25	14	3	1	0	0	0	0	0	0
0	0	0	0	0	0	0	3	6	37	34	27	18	5	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	13	33	25	36	10	5	0	0	0	0	0	0	0	0

Speed = 40 fps Load = 2500 lb Water depth = .500 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = -1 in. z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 29

0	0	0	0	0	0	0	0	0	0	0	2	4	6	6	10	15	19	15	17	13	13
0	0	0	0	0	0	0	2	0	2	2	4	6	8	10	15	17	19	15	15	10	10
0	0	0	0	0	0	0	2	0	2	4	6	8	11	17	19	19	23	19	13	10	8
0	0	0	0	0	0	2	2	2	4	6	8	10	13	21	23	21	17	13	8	8	4
0	0	0	0	0	0	2	2	4	6	6	10	10	19	23	23	25	21	10	6	4	4
0	0	0	0	2	2	2	4	6	8	11	19	29	30	27	25	21	8	6	6	6	2
0	0	0	0	0	2	2	4	6	10	13	23	21	29	30	19	19	8	4	2	2	0
0	0	0	0	0	2	2	6	8	11	19	27	36	34	30	21	11	8	4	0	0	0
0	0	0	0	2	2	6	8	11	17	23	27	38	40	34	25	15	6	2	2	0	0
0	0	0	2	2	4	6	10	13	17	30	38	42	48	32	19	10	2	2	0	0	0
0	0	0	0	2	2	4	8	11	19	34	44	55	36	25	6	2	0	0	0	0	0
0	0	0	0	2	2	4	8	13	19	32	53	59	51	21	2	0	0	0	0	0	0
0	0	0	0	0	2	4	8	11	19	38	51	57	40	13	2	0	0	0	0	0	0
0	0	0	0	0	2	6	6	13	25	38	61	49	29	10	0	0	0	0	0	0	0
0	0	0	0	0	0	4	6	11	38	51	55	38	13	4	0	0	0	0	0	0	0
0	0	0	0	0	0	4	10	15	38	53	49	25	10	0	0	0	0	0	0	0	0
0	0	0	0	0	0	6	11	21	49	59	48	21	8	4	0	0	0	0	0	0	0
0	0	0	0	0	2	6	10	32	51	61	40	15	6	0	0	0	0	0	0	0	0
0	0	0	0	0	0	6	19	38	88	67	32	13	10	0	0	0	0	0	0	0	0
0	0	0	0	2	6	10	36	67	91	53	25	11	6	0	0	0	0	0	0	0	0
0	0	0	0	0	6	25	53	103	88	38	13	6	0	0	0	0	0	0	0	0	0
0	0	0	0	6	15	36	93	131	67	15	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 2500 lb   Water depth = .500 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = −1 in.   z = 16 in.

Flow values are in gallons per minute × 10^2

Figure A1. Continued.

Run 30

0	0	0	0	3	3	3	5	3	8	8	8	13	18	23	28	28	28	30	28	30	25
0	0	0	0	3	3	3	3	5	8	10	15	20	23	25	33	38	36	30	28	28	20
0	0	0	3	3	3	3	3	5	10	13	23	25	30	36	41	46	38	30	28	23	15
0	0	0	3	3	3	3	5	5	13	18	23	25	33	41	38	38	38	33	20	18	10
0	0	0	3	5	8	8	8	13	15	20	25	28	46	41	51	38	36	23	18	5	3
0	0	0	3	3	3	5	8	10	13	18	18	56	48	53	41	36	25	10	5	5	3
0	0	0	3	3	3	5	8	10	15	23	28	51	48	53	41	25	15	10	5	5	3
0	0	3	3	3	3	3	5	10	13	23	38	53	53	48	36	23	23	8	3	3	0
0	3	3	3	3	5	8	13	15	18	28	46	56	68	48	30	18	5	5	5	5	5
3	3	3	3	5	3	8	10	18	23	38	51	71	58	41	20	13	3	3	3	3	3
3	3	3	3	3	5	8	13	20	23	33	53	76	58	25	13	5	3	3	5	8	8
3	3	3	3	3	5	8	13	18	25	38	66	71	51	20	10	5	3	5	5	5	5
3	3	3	3	3	5	8	10	18	30	43	81	61	28	20	8	8	5	5	8	8	8
3	3	3	3	3	5	10	15	25	30	61	76	53	25	13	5	5	5	3	3	3	3
0	0	0	0	0	3	5	13	18	51	89	86	51	25	13	5	5	5	5	5	5	5
0	0	0	0	3	5	10	15	25	63	107	81	43	15	10	5	5	3	3	3	3	3
0	0	0	0	3	5	8	25	51	107	107	58	30	15	8	0	0	0	0	0	0	0
0	0	0	0	5	8	15	38	76	137	99	33	23	5	5	0	0	0	0	0	0	0
0	0	0	0	3	10	28	71	139	81	56	25	13	3	0	0	0	0	0	0	0	0
0	0	0	3	8	20	56	122	165	109	51	15	3	3	3	0	0	0	0	0	0	0
0	0	0	5	13	41	76	165	190	66	20	5	3	3	3	0	0	0	0	0	0	0
0	0	0	5	23	56	150	243	160	28	13	5	3	3	0	0	0	0	0	0	0	0

Speed = 80 fps   Load = 2500 lb   Water depth = .500 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = -1 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 31

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	4	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	3	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	3	5	5	4	4
0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	5	5	4	3	3
0	0	0	0	0	0	0	0	0	0	0	1	1	1	3	3	4	4	5	4	3	3
0	0	0	0	0	0	0	0	0	1	1	3	3	4	4	5	3	6	4	5	3	4
0	0	0	0	0	0	0	0	0	1	1	4	4	5	6	6	6	6	6	5	4	3
0	0	0	0	0	0	0	0	1	1	3	3	5	6	9	9	10	10	4	4	5	1
0	0	0	0	0	0	0	0	1	0	3	6	8	11	8	14	9	4	3	1	0	0
0	0	0	0	0	0	0	0	1	3	6	11	13	19	11	14	13	5	1	1	1	0
0	0	0	0	0	0	0	0	1	1	8	14	23	36	25	22	10	3	3	0	0	1
0	0	0	0	0	0	0	0	3	5	9	24	38	39	38	20	8	3	1	1	1	0
0	0	0	0	0	0	0	0	1	5	14	36	53	57	34	13	8	1	1	1	0	0
0	0	0	0	0	0	0	0	1	8	16	70	90	63	22	11	5	1	0	1	0	0
0	0	0	0	0	0	0	0	3	10	43	88	84	37	9	1	0	0	4	1	0	0
0	0	0	0	0	0	0	1	6	15	76	126	62	15	1	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	5	28	120	103	38	4	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	15	67	174	65	9	0	0	0	0	0	0	0	0	0

Speed = 40 fps Load = 500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = −1 in. z = 16 in.

Flow values are in gallons per minute × 10^2

Figure A1. Continued.

Run 32

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	4	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	4	6	6	6
0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	4	4	6	6	6	4
0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	4	6	6	6	6	6	6
0	0	0	0	0	0	0	0	0	0	0	2	4	4	6	8	10	11	8	10	8	8
0	0	0	0	0	0	0	0	0	0	0	0	2	4	6	6	8	10	13	10	6	6
0	0	0	0	0	0	0	0	0	0	2	2	4	4	6	6	8	10	11	8	6	6
0	0	0	0	0	0	0	0	0	0	2	2	4	6	10	11	8	51	42	6	6	4
0	0	0	0	0	0	0	0	0	2	2	4	6	17	25	32	48	49	44	17	10	8
0	0	0	0	0	0	0	0	2	4	4	6	13	21	32	78	80	57	29	17	6	4
0	0	0	0	0	0	0	0	2	6	6	8	15	36	67	88	97	57	25	11	8	4
0	0	0	0	0	0	0	0	4	6	6	11	17	49	74	110	89	38	19	11	6	6
0	0	0	0	0	0	2	2	2	6	6	13	29	78	95	103	49	30	11	6	6	4
0	0	0	0	0	0	0	2	4	4	6		76	95	133	72	17	13	10	4	4	4
0	0	0	0	0	0	0	2	4	8	19		40		78	21	11	10	6	2	2	0
0	0	0	0	0	0	0	4	6	15	25	114	131	76	21	13	8	6	2	2	2	2
0	0	0	0	0	0	2	4	10	29	86	162	76	27	13	2	2	2	2	0	2	2
0	0	0	0	0	0	0	8	19	72	164	110	29	10	2	2	2	0	0	0	2	2
0	0	0	0	0	0	6	15	59	118	133	42	10	2	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	25	114	205	57	11	0	0	0	0	0	0	0	0	0	2
0	0	0	0	4	17	63	194	105	13	0	0	0	0	0	0	0	0	0	0	0	0
2	2	2	2	0	0	32	148	209	27	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = -1 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 33

0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	5	5	10	15	18	13	10
0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	10	15	46	25	25	18	13
0	0	0	0	0	0	0	0	0	0	0	5	5	10	13	15	20	28	43	36	20	15
0	0	0	0	0	0	0	0	0	0	3	5	8	13	18	20	41	48	53	48	30	18
0	0	0	0	0	0	0	0	0	0	3	5	8	13	23	33	53	81	71	36	25	15
0	0	0	0	0	0	0	0	0	3	5	5	8	13	20	46	99	134	91	61	25	23
0	0	0	0	0	0	0	0	0	3	3	5	8	10	25	61	114	200	112	66	25	10
0	0	0	0	0	0	0	0	0	0	3	3	8	18	28	61	172	228	147	53	33	13
0	0	0	0	0	0	0	0	0	3	3	5	10	23	53	91	228	203	119	48	13	13
0	0	0	0	0	0	0	0	0	0	3	5	13	25	43	107	185	147	51	20	10	5
0	0	0	0	0	0	0	0	0	3	3	8	20	48	76	162	101	51	25	10	5	5
0	0	0	0	0	0	0	0	0	3	3	10	33	56	107	114	66	30	10	5	3	3
0	0	0	0	0	0	0	0	3	8	13	25	53	86	99	56	38	10	8	5	3	3
0	0	0	0	0	0	0	0	3	5	20	43	79	101	71	36	15	10	5	3	3	0
0	0	0	0	0	0	0	0	5	10	33	76	112	84	48	30	10	5	3	3	0	0
0	0	0	0	0	0	0	3	5	20	74	127	122	53	25	10	8	5	0	0	0	0
0	0	0	0	0	0	0	3	10	51	152	160	61	25	8	8	8	0	0	0	0	0
0	0	0	0	0	0	0	5	23	132	203	79	25	10	5	0	0	0	0	0	0	0
0	0	0	0	0	0	0	10	114	251	117	25	8	3	3	0	0	0	0	0	0	0
0	0	0	0	0	0	5	51	254	216	28	8	0	0	0	0	0	0	0	0	0	0
0	0	3	0	0	5	28	228	388	53	5	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	8	127	492	124	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 80 fps   Load = 500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = -1 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 34

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3	4	3	4	4
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3	3	4	4	4	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	4	4	3	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	4	6	5	5	5	5
0	0	0	0	0	0	0	0	0	1	0	1	1	3	4	3	4	4	4	4	1	3
0	0	0	0	0	0	0	0	0	0	3	1	3	3	4	5	6	5	6	4	4	3
0	0	0	0	0	0	0	0	0	1	4	4	4	5	8	6	8	5	5	4	3	3
0	0	0	0	0	0	1	1	3	3	3	4	5	6	8	6	5	5	4	1	3	1
0	0	0	0	0	1	1	1	4	4	5	5	5	9	8	6	6	4	4	3	1	1
0	0	0	0	0	0	1	4	3	4	4	13	14	11	15	10	5	4	3	1	0	1
0	0	0	0	0	1	3	3	4	4	6	8	10	11	15	9	5	5	4	3	0	1
0	0	0	0	1	1	3	4	4	6	8	11	19	13	11	6	4	4	1	1	1	0
0	0	0	0	1	1	4	4	5	9	9	11	18	15	15	9	6	4	3	1	0	1
0	0	0	0	1	1	1	1	4	8	10	24	25	16	10	8	6	3	3	1	0	0
0	0	0	0	0	1	1	3	5	9	8	20	20	23	10	6	3	1	1	0	0	0
0	0	0	0	0	0	1	1	4	8	18	29	30	24	15	5	3	1	0	0	0	0
0	0	0	0	0	1	4	5	9	13	25	34	28	22	10	4	0	0	0	0	0	0
0	0	0	0	0	1	3	4	10	16	25	32	32	22	8	1	0	1	0	0	0	1
0	0	0	0	0	1	1	5	9	15	25	34	24	15	8	4	1	1	1	1	1	0
0	0	0	0	1	1	1	4	6	24	30	34	15	13	5	0	1	1	1	0	1	0
0	0	3	0	0	0	1	3	5	24	36	28	13	5	0	0	0	0	0	0	0	0
0	0	0	0	0	1	1	3	13	28	38	23	10	4	1	0	0	0	0	0	0	0

Speed = 40 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = -1 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 35

0	0	0	0	0	0	0	2	0	2	2	6	8	8	15	13	17	15	19	13	10	8
0	0	0	0	0	0	0	2	2	2	4	6	10	17	19	23	19	19	15	10	8	4
0	0	0	0	0	0	2	2	2	6	8	11	10	19	23	21	21	17	11	8	6	2
0	0	0	0	0	2	2	4	4	6	8	13	19	27	27	25	19	19	10	0	0	0
0	0	0	0	0	0	2	4	8	8	11	19	23	27	27	49	19	8	8	2	2	2
0	0	0	0	0	0	2	4	6	10	17	25	27	30	29	30	13	6	6	4	2	2
0	0	0	0	0	2	4	6	8	13	17	27	27	34	30	29	8	6	4	2	2	2
0	0	0	0	0	2	4	6	8	11	21	34	34	40	32	21	6	2	0	0	0	0
0	0	0	0	2	2	4	4	8	17	23	32	44	46	32	13	10	2	0	0	0	0
0	0	0	0	0	2	4	6	8	19	30	38	53	55	25	11	6	4	0	0	0	0
0	0	0	0	2	2	2	6	10	17	38	48	55	48	21	10	4	2	0	0	0	0
0	0	0	0	0	2	2	4	8	19	40	63	63	46	25	10	6	2	0	0	0	0
0	0	0	0	0	2	4	8	11	27	49	59	59	42	25	6	4	4	0	0	0	0
0	0	0	0	0	2	4	10	15	32	51	63	59	25	6	6	0	0	0	0	0	0
0	0	0	0	0	0	4	8	19	48	74	57	67	19	6	0	0	0	0	0	0	0
0	0	0	0	0	2	2	13	23	42	65	51	42	11	8	0	0	0	0	0	0	0
0	0	0	0	0	0	4	15	34	63	61	42	21	11	8	0	0	0	0	0	0	0
0	0	0	0	0	2	6	25	55	74	63	53	13	4	2	0	0	0	0	0	0	0
0	0	0	0	2	4	10	32	61	95	70	38	11	6	0	0	0	0	0	0	0	0
0	0	0	0	0	2	15	40	88	84	57	19	2	2	0	0	0	0	0	0	0	0
0	0	0	0	2	6	27	80	112	99	36	6	4	0	0	0	0	0	0	0	0	0
0	0	0	0	2	6	53	124	120	80	25	4	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = -1 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 36

0	0	3	8	8	10	10	8	10	15	18	25	33	41	43	51	48	33	28	20	13	8
0	0	5	5	5	5	8	8	10	10	15	33	36	46	51	53	51	30	23	0	0	0
0	3	3	5	5	3	5	8	10	13	23	36	46	51	58	56	43	23	13	13	8	5
3	3	3	3	3	3	3	5	8	13	25	30	46	53	63	53	61	20	10	3	0	3
3	3	3	3	3	5	5	8	10	18	28	33	48	71	71	51	28	20	3	0	3	0
3	3	3	3	3	5	5	8	13	18	33	38	51	68	71	48	23	10	3	0	0	0
3	3	3	3	3	3	5	8	13	18	33	43	96	76	66	66	15	3	3	0	0	0
3	3	3	3	3	3	3	5	10	18	36	48	79	86	68	36	13	3	3	0	0	0
3	3	3	3	3	3	3	8	13	25	38	58	91	79	56	18	8	3	0	0	0	0
3	3	3	3	0	3	5	8	13	28	48	74	91	79	43	20	0	0	0	0	0	0
3	0	0	0	0	5	8	13	18	30	53	104	96	76	28	10	3	0	0	0	0	0
0	0	3	5	5	8	10	8	13	46	66	107	94	68	28	10	3	0	0	0	0	0
3	3	3	0	3	5	8	20	15	48	81	127	76	36	18	10	3	0	0	0	0	0
0	0	0	3	3	8	13	23	33	61	101	86	68	20	13	8	3	0	0	0	0	0
0	0	0	3	3	5	10	28	38	84	112	96	46	20	10	5	3	0	0	3	0	3
0	0	0	0	3	5	10	28	61	129	74	38	10	10	3	3	0	0	0	0	0	0
0	0	0	0	3	8	20	36	86	155	155	66	23	13	5	5	3	0	3	3	0	0
0	0	0	3	3	8	30	58	152	200	104	43	23	5	3	0	0	0	0	3	3	0
0	0	0	0	5	13	38	99	218	203	79	23	5	3	3	0	0	0	0	0	3	0
0	0	0	3	8	18	66	165	274	152	36	13	10	3	0	0	0	0	0	0	0	0
0	0	0	3	10	38	101	266	304	68	20	8	3	0	0	0	0	0	0	0	0	0
0	0	3	8	15	81	228	360	172	33	5	3	3	0	0	0	0	0	0	0	0	0

Speed = 80 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = -1 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A1. Continued.

Run 37

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	8	8	8	8	8
0	0	0	0	0	0	0	0	0	0	0	3	3	3	5	5	8	8	8	10	10	13
0	0	0	0	0	0	0	0	0	0	0	3	3	3	5	8	8	8	10	13	15	18
0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	8	8	10	15	18	18	15
0	0	0	0	0	0	0	0	0	0	3	3	3	3	5	8	10	13	18	23	28	25
0	0	0	0	0	0	0	0	3	3	5	8	8	8	10	15	20	23	28	28	30	25
0	0	0	0	0	0	0	3	3	3	5	8	8	10	10	18	23	33	41	36	25	30
0	0	0	0	0	0	3	3	3	3	5	8	10	15	23	25	30	41	41	33	25	25
0	0	0	0	0	0	3	3	3	8	10	15	20	20	23	33	38	41	33	25	28	25
0	0	0	0	0	3	3	3	5	5	10	13	25	25	30	43	43	33	25	28	28	20

Speed = 80 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = −1 in.   z = 46.5 in.

Flow values are in gallons per minute × 10^2

Figure A1. Concluded.

Run 38

			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
					0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
					0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
					0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
					0	0	0	0	0	0	0	0	1	3	3	3	3	1	1	1	1
					0	0	0	0	0	1	1	3	3	5	5	3	3	0	3	0	0
					0	0	0	0	0	1	4	1	4	4	4	0	1	3	1	1	1
				0	0	0	0	0	1	4	4	4	1	3	3	1	1	3	1	1	0
				0	0	0	0	1	1	4	3	5	4	5	4	1	3	1	3	1	1
				0	0	0	0	3	3	5	6	5	4	4	3	3	0	0	1	0	1
			0	0	1	1	3	4	8	10	6	4	3	3	3	3	1	1	0	0	1
		0	0	0	0	1	8	13	15	9	8	6	0	1	1	0	0	0	0	0	1
0	0	0	0	0	1	8	14	25	13	9	9	4	4	0	0	0	1	3	1	1	0
0	0	0	1	6	6	22	25	25	29	22	8	0	1	0	0	0	0	1	0	1	0
0	0	1	3	8	13	34	38	34	38	23	5	0	0	1	0	0	0	0	0	1	1
1	1	3	4	8	16	39	47	58	33	15	0	0	0	0	0	0	1	1	1	1	0
0	1	3	5	11	52	63	84	41	24	4	0	0	0	0	0	0	0	0	0	0	0
1	1	4	16	41	84	101	63	38	11	1	0	0	0	0	0	0	0	0	0	0	0
1	3	9	30	82	98	41	24	6	4	0	0	0	0	0	0	0	0	0	0	0	0
1	4	18	55	114	34	23	8	3	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 40 fps Load = 500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = 14 in. z = 16 in.

Flow values are in gallons per minute $\times 10^2$

Figure A2. Fuselage-installed test configuration with 6.00 × 6 bias-ply tire.

Run 39

			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	2	4	4	4	4	4	4	2	2	0	0
				0	0	0	0	0	0	2	4	8	11	10	6	6	6	2	4	2	2
					0	0	0	0	0	8	13	17	13	10	11	11	8	4	2	2	2
					0	0	0	0	8	17	25	19	17	13	10	6	4	4	2	4	2
					0	0	0	2	23	30	32	23	19	10	6	4	4	4	2	2	2
					0	0	0	10	48	48	38	32	15	8	6	4	6	4	4	4	2
					0	0	2	38	72	74	53	25	11	6	4	4	4	2	4	4	2
				0	0	0	6	78	91	78	57	23	6	4	2	2	2	2	2	2	2
				0	0	2	2	76	108	95	57	13	4	2	2	2	2	0	2	2	2
				0	0	15	49	95	133	127	49	4	2	4	2	2	2	2	2	2	2
			0	0	10	25	61	129	158	114	10	2	2	2	2	2	2	2	2	2	2
		0	0	6	23	53	93	171	118	21	4	2	0	2	2	2	2	2	0	0	0
0	0	0	4	19	42	76	135	114	34	6	2	0	0	0	2	2	2	0	0	0	0
0	0	6	19	48	78	118	114	27	4	2	2	0	0	0	0	2	0	0	2	2	0
2	4	19	44	80	108	114	0	2	2	2	0	2	0	0	0	0	0	0	0	0	0
10	21	38	89	133	108	51	4	0	0	2	0	0	0	0	0	0	0	0	0	0	0
10	34	78	116	120	40	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	65	129	137	51	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	114	173	133	21	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	186	190	40	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps Load = 500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = 14 in. z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A2. Continued.

Run 40

			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	3	8	5	3	3	3	0	0	0	0	0
				0	0	0	0	0	0	0	10	10	20	8	5	3	3	0	0	0	0
				0	0	0	0	0	0	8	23	25	23	13	10	5	3	3	0	0	0
					0	0	0	0	8	36	53	43	33	20	13	10	3	3	3	3	0
					0	0	0	3	36	68	76	56	38	20	8	8	3	3	3	3	3
					0	0	0	15	56	86	81	68	36	25	13	10	10	5	3	3	3
					0	0	3	25	76	104	112	101	43	20	15	15	8	8	5	8	3
					0	0	5	51	94	165	172	96	33	13	13	10	13	10	8	5	5
				0	0	3	23	86	165	208	147	58	18	13	8	8	8	5	5	3	3
				0	0	0	0	109	180	172	68	43	15	8	5	8	5	5	5	5	3
				0	5	48	99	127	152	68	30	15	3	3	3	5	5	5	3	5	5
			0	0	33	63	96	139	76	30	15	5	5	5	5	5	3	3	3	3	5
		0	0	20	46	79	101	81	46	15	8	8	3	3	3	8	3	3	3	3	5
0	0	0	10	30	61	101	114	63	20	13	5	5	5	5	8	5	5	3	5	5	5
0	5	10	25	56	99	147	68	28	15	8	8	3	3	5	5	3	3	3	3	5	5
3	8	15	53	101	137	81	28	15	13	10	3	5	3	3	5	3	3	5	5	5	8
8	18	46	109	178	96	28	10	10	10	3	3	3	3	5	3	3	3	5	3	3	3
8	38		112	190	107	30	10	3	3	3	3	5	0	3	0	0	3	3	3	3	3
25	99	226	178	51	10	0	0	3	3	3	3	3	3	0	3	3	3	0	0	0	0
51	228	254	71	8	0	3	0	3	0	0	3	0	0	0	0	0	0	3	3	3	0
175	53	152	13	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 80 fps Load = 500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = 14 in. z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A2. Continued.

Run 41

			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	3	3
				0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	3	3	1
				0	0	0	0	0	0	0	0	0	0	0	1	3	4	3	3	3	3
				0	0	0	0	0	0	0	0	1	1	3	3	4	4	4	3	3	3
				0	0	0	0	0	0	0	1	3	4	4	5	5	5	4	4	3	3
				0	0	0	0	0	0	0	1	4	5	4	5	5	4	5	4	1	1
				0	0	0	0	0	0	1	4	8	8	6	6	5	5	4	4	4	3
				0	0	0	0	0	1	6	11	14	11	8	6	6	5	5	4	3	1
				0	0	0	0	0	4	11	14	13	11	8	6	4	3	1	1	1	1
				0	0	0	1	4	11	18	18	11	8	8	6	5	4	4	1	1	1
				0	0	0	1	16	15	19	11	13	9	4	5	3	3	1	1	1	1
			0	0	0	0	4	25	20	15	11	14	5	4	3	3	1	1	1	0	0
		0	0	4	0	4	22	28	23	13	13	8	4	4	3	1	0	0	1	0	0
0	0	0	8	18	19	24	39	27	22	15	6	4	4	1	0	0	0	0	0	0	0
0	0	0	3	22	34	34	41	25	13	5	4	3	3	1	1	0	0	0	0	0	0
0	0	5	19	27	42	41	38	25	13	10	1	1	1	1	1	1	1	1	0	1	0
4	6	13	23	36	55	52	37	23	14	13	8	3	1	1	1	0	0	0	0	0	0
4	8	13	24	37	63	42	29	14	1	1	0	0	0	0	0	0	0	0	0	0	0
4	5	13	25	34	51	38	20	6	1	1	0	0	0	0	0	0	0	0	0	0	0
4	11	13	28	43	39	43	11	3	1	0	0	0	0	0	0	0	0	0	0	0	0
1	6	15	37	48	42	19	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 40 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute $\times 10^2$

Figure A2. Continued.

Run 42

			0	0	0	0	0	0	0	0	0	0	2	6	11	11	11	11	11	11	11
				0	0	0	0	0	0	0	0	4	11	17	17	19	13	13	8	4	6
				0	0	0	0	0	0	0	4	19	27	21	23	21	13	6	4	4	4
				0	0	0	0	0	0	2	15	32	29	27	19	15	13	8	6	4	4
					0	0	0	0	0	10	49	36	30	29	21	15	8	6	4	4	2
					0	0	0	2	4	34	55	40	34	25	13	10	8	4	2	2	2
					0	0	0	2	17	57	49	36	25	15	8	4	4	2	2	2	2
					0	0	2	6	46	68	46	27	21	11	8	8	4	4	4	4	4
					0	0	4	19	82	59	34	11	11	10	10	6	4	4	2	2	2
				0	0	0	6	57	68	44	19	10	8	6	6	6	4	4	2	2	0
				0	0	0	46	82	63	23	10	10	6	4	2	2	2	2	2	2	0
				0	2	40	91	70	34	13	6	6	2	2	2	2	2	2	0	0	0
			0	0	27	76	76	42	19	6	4	4	2	2	0	2	0	0	0	0	0
		0	0	11	70	74	53	32	6	2	2	0	2	2	2	2	0	0	0	0	0
0	0	0	15	72	76	63	46	10	0	0	0	2	0	2	0	2	0	2	0	0	0
0	4	27	53	61	63	48	19	4	2	0	0	2	0	2	0	0	0	0	0	0	0
6	4	32	42	63	48	36	17	4	2	0	0	0	0	0	0	0	0	0	0	0	0
11	19	32	53	70	59	21	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0
11	21	42	76	76	42	17	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0
17	38	80	91	61	30	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	67	89	86	76	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	122	114	76	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps Load = 2500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = 14 in. z = 16 in.

Flow values are in gallons per minute × 10^2

Figure A2. Continued.

Run 43

			0	0	0	0	0	0	0	0	0	10	38	51	25	30	25	23	18	13	13
				0	0	0	0	0	0	0	15	46	56	51	38	28	28	23	18	10	8
				0	0	0	0	0	0	18	51	79		51	30	23	28	25	20	13	8
				[illegible]	0	0	0	0	8	48	76	71	53	25	36	23	20	13	0	10	10
				[illegible]	0	0	0	0	18	76	76	58	51	41	30	25	23	13	10	10	8
				[illegible]	0	0	0	5	51	96	79	58		33	25	18	8	10	10	5	8
					0	0	3	20	79	86	56	46	25	18	10	8	5	8	8	5	5
				[illegible]	0	0	5	41	81	74	51	30	15	10	8	8	8	8	8	8	8
				[illegible]	0	3	20	94	117	48	41	10	8	3	3	5	3	3	3	3	3
				[illegible]	0	8	76	86	66	43	23	8	3	0	3	3	3	3	3	3	3
				0	0	10	99	74	43	15	8	0	3	3	5	0	3	5	5	3	3
				0	13	96	91	51	20	10	0	3	3	3	3	3	3	3	3	3	3
			0	0	101	96	63	20	8	3	3	3	3	3	3	3	3	3	3	3	3
		0	0	68	99	81	38	18	8	3	3	0	3	3	3	3	3	5	3	5	3
0	0	0	58	86	89	51	25	8	3	0	0	0	3	0	3	3	3	3	3	3	3
8	25	51	74	99	81	51	15	8	3	0	0	0	0	0	0	0	0	0	0	0	0
25	38	58	86	96	66	33	5	3	0	3	3	0	3	0	3	3	3	0	0	0	0
25	41	76	112	94	46	20	5	0	0	0	0	0	0	3	0	0	3	3	5	0	3
25	76	127	127	61	18	10	5	0	0	0	0	0	0	0	3	0	3	0	0	0	0
63	122	165	96	30	5	3	0	0	0	0	0	0	0	0	3	0	0	3	0	3	0
107	190	150	63	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
203	216	117	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

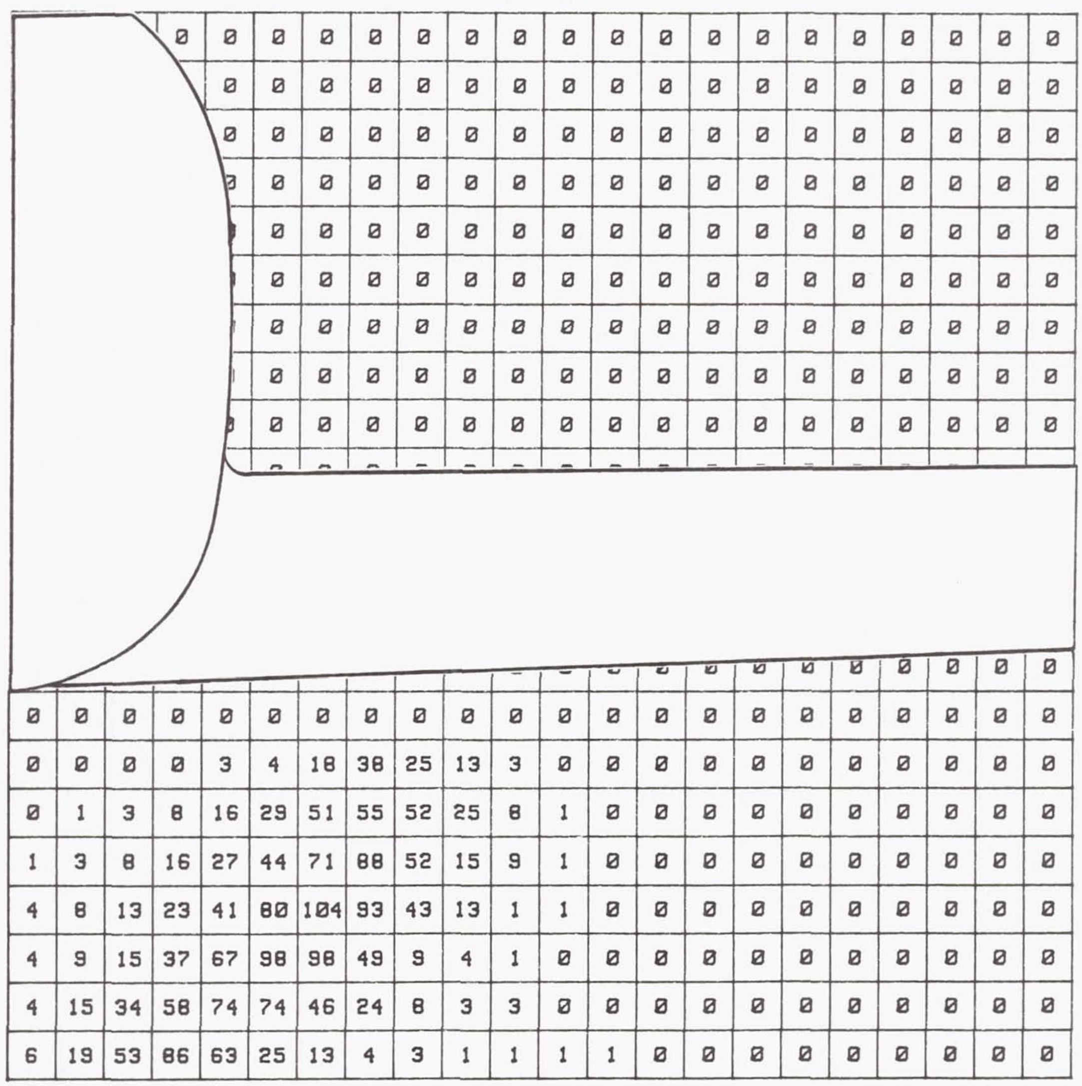
Speed = 80 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute × 10^2

Figure A2. Concluded.

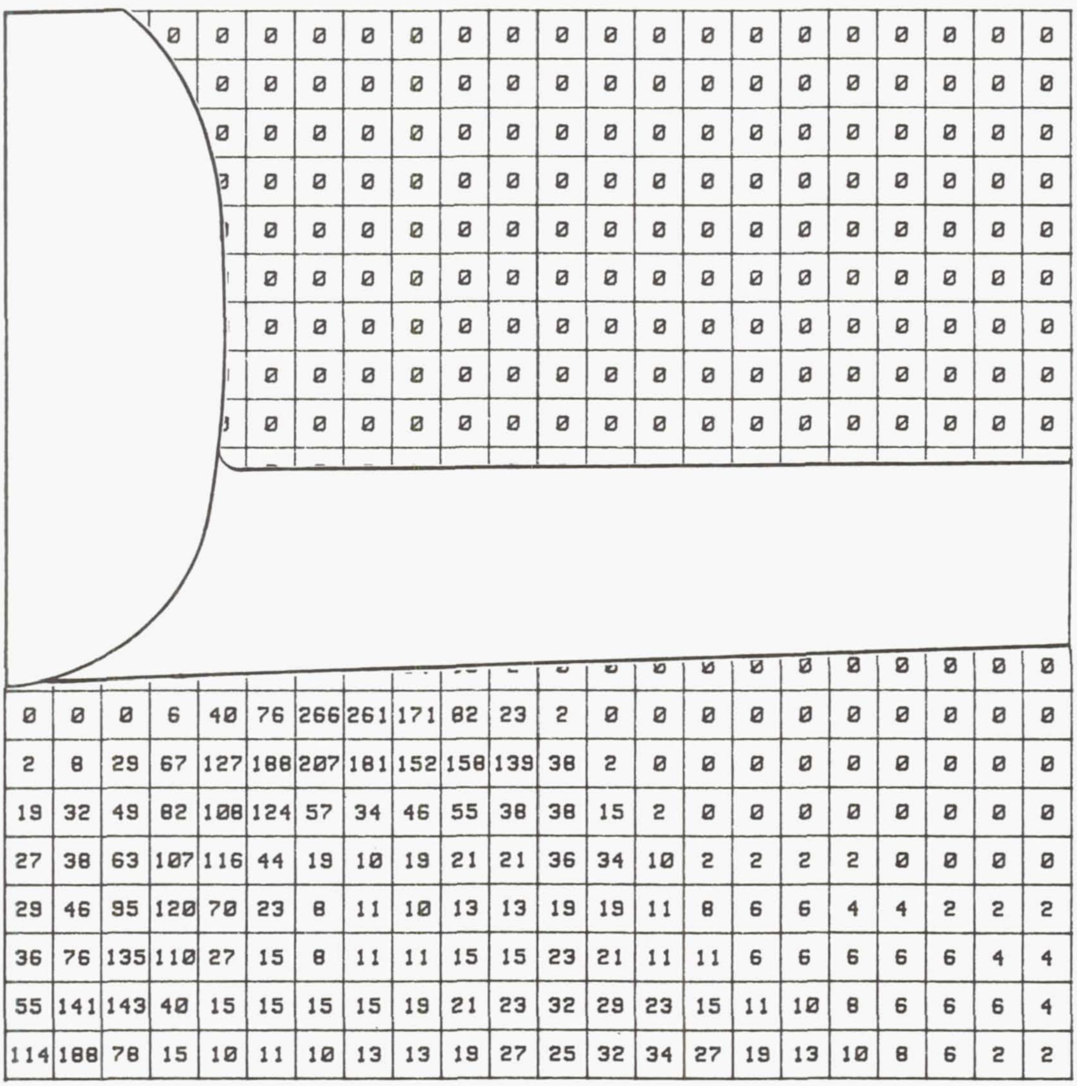
Run 44



Speed = 40 fps Load = 500 lb Water depth = .625 in. Tire pressure = 35 psi
Coordinates: x = 199 in. y = 14 in. z = 16 in.
Flow values are in gallons per minute x 10^2

Figure A3. Fuselage-installed test configuration with wing forward with 6.00 × 6 bias-ply tire.

Run 45



Speed = 60 fps Load = 500 lb Water depth = .625 in. Tire pressure = 35 psi

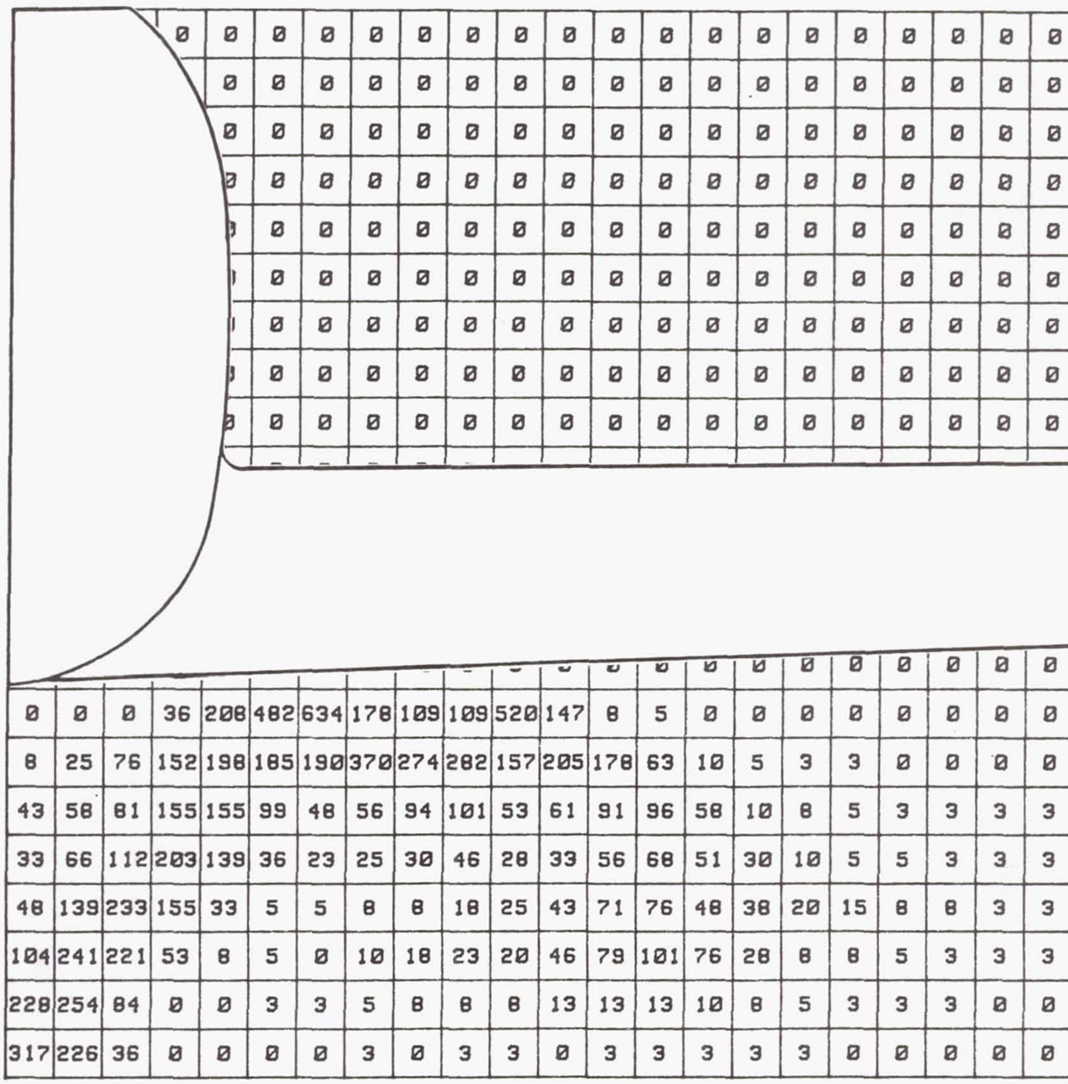
Coordinates: x = 199 in. y = 14 in. z = 16 in.

Flow values are in gallons per minute $\times 10^2$

Figure A3. Continued.

C-2

Run 46



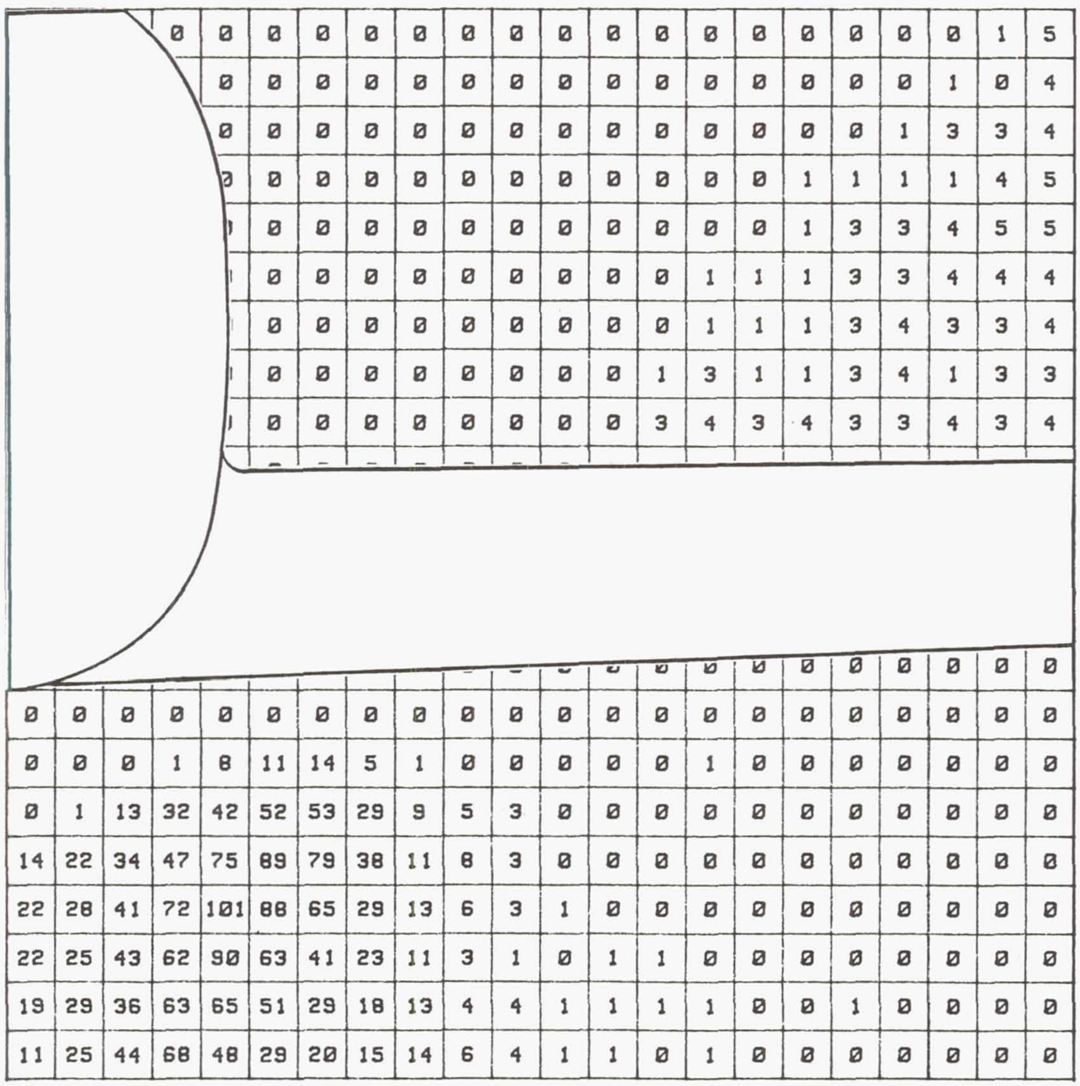
Speed = 80 fps Load = 500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = 14 in. z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A3. Continued.

Run 47



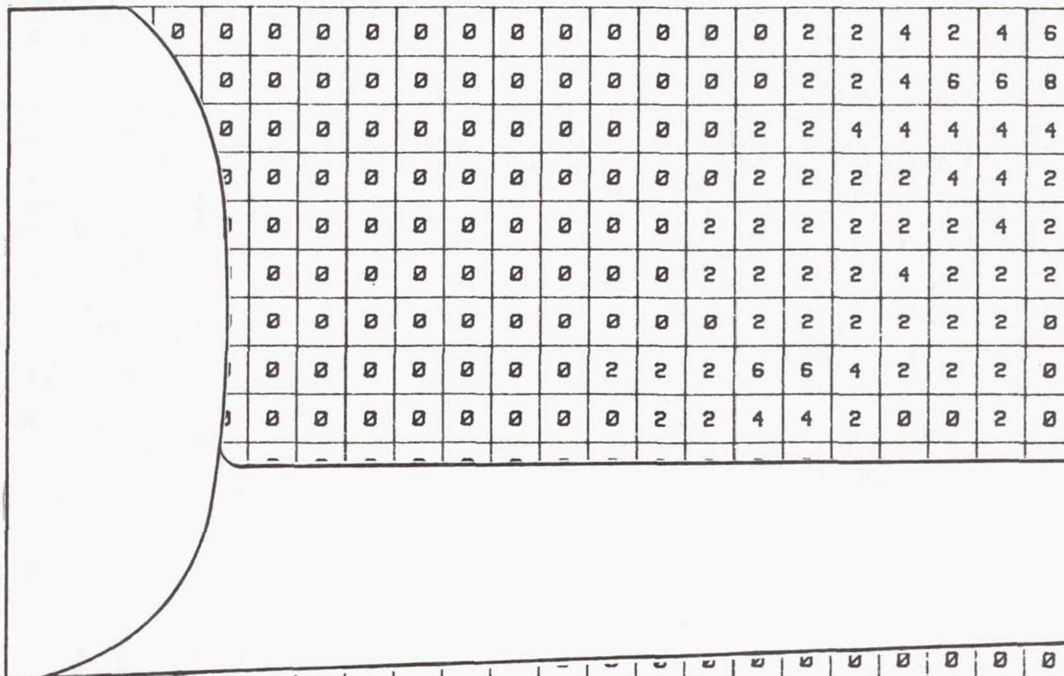
Speed = 40 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A3. Continued.

Run 48



0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	2	4	6
	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4	6	6	8
	0	0	0	0	0	0	0	0	0	0	0	2	2	4	4	4	4	4
		0	0	0	0	0	0	0	0	0	0	2	2	2	2	4	4	2
		0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	4	2
		0	0	0	0	0	0	0	0	0	2	2	2	2	4	2	2	2
		0	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	0
		0	0	0	0	0	0	0	2	2	2	6	6	4	2	2	2	0
		0	0	0	0	0	0	0	0	2	2	4	4	2	0	0	2	0

0	0	0	8	57	122	95	38	6	2	2	0	0	0	0	0	2	0	0	2	0	0
4	6	57	61	264	242	228	223	95	8	0	2	0	0	0	0	0	2	0	0	2	0
46	67	95	133	99	57	44	65	122	34	6	0	0	0	0	2	0	0	0	0	0	0
42	57	82	76	40	21	21	32	59	68	19	6	0	0	0	0	0	0	2	0	0	2
38	68	84	70	44	19	8	8	21	38	30	17	6	0	0	0	0	0	2	2	0	0
42	97	116	70	36	10	6	6	11	19	21	19	6	4	4	0	0	0	2	0	0	2
61	129	133	63	23	6	6	8	10	10	21	25	17	6	4	4	2	2	4	2	2	2
84	135	112	40	10	6	6	6	15	21	34	36	40	38	21	6	2	2	2	0	0	0

Speed = 60 fps Load = 2500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = 14 in. z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A3. Continued.

Run 49

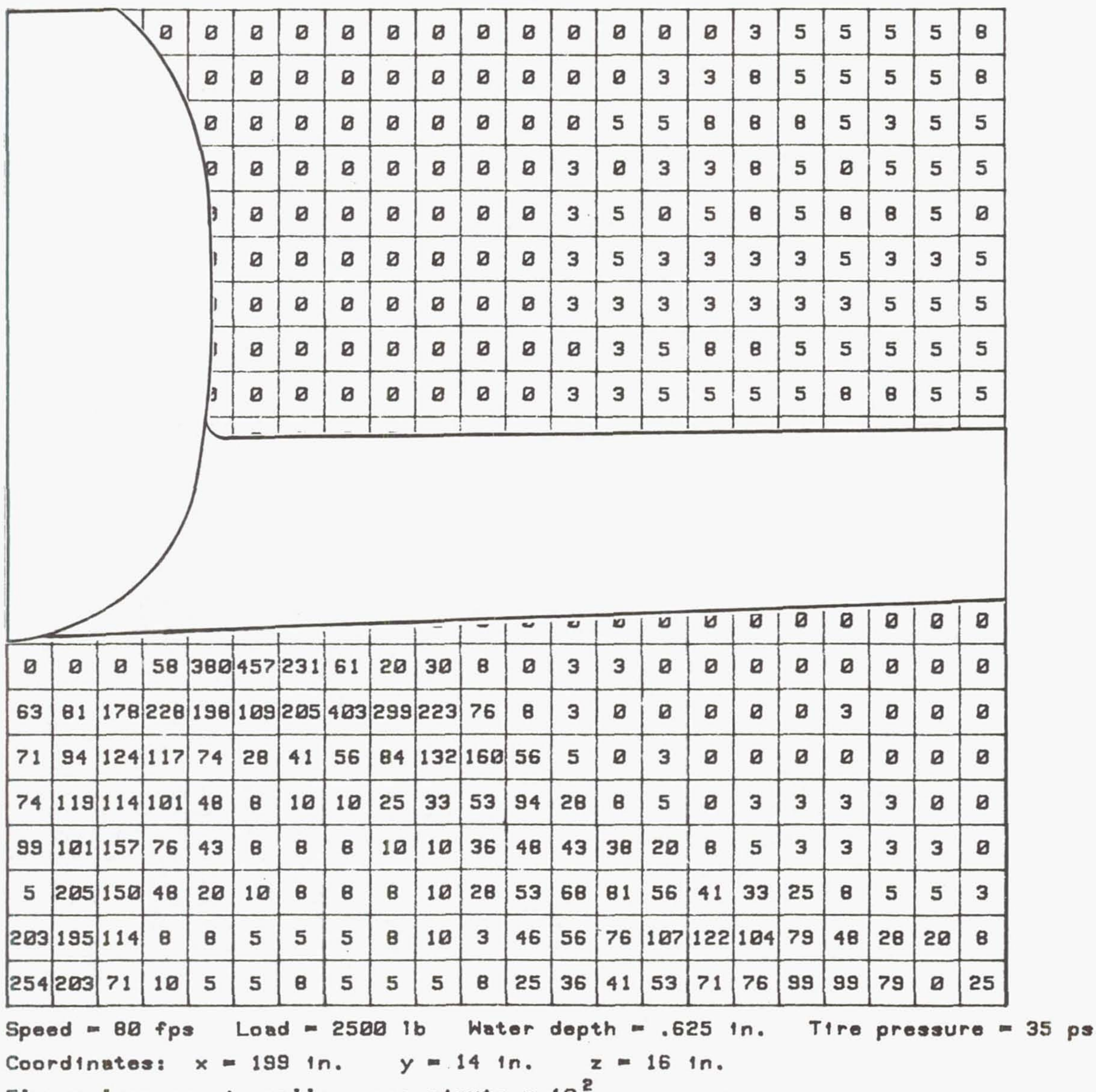


Figure A3. Concluded.

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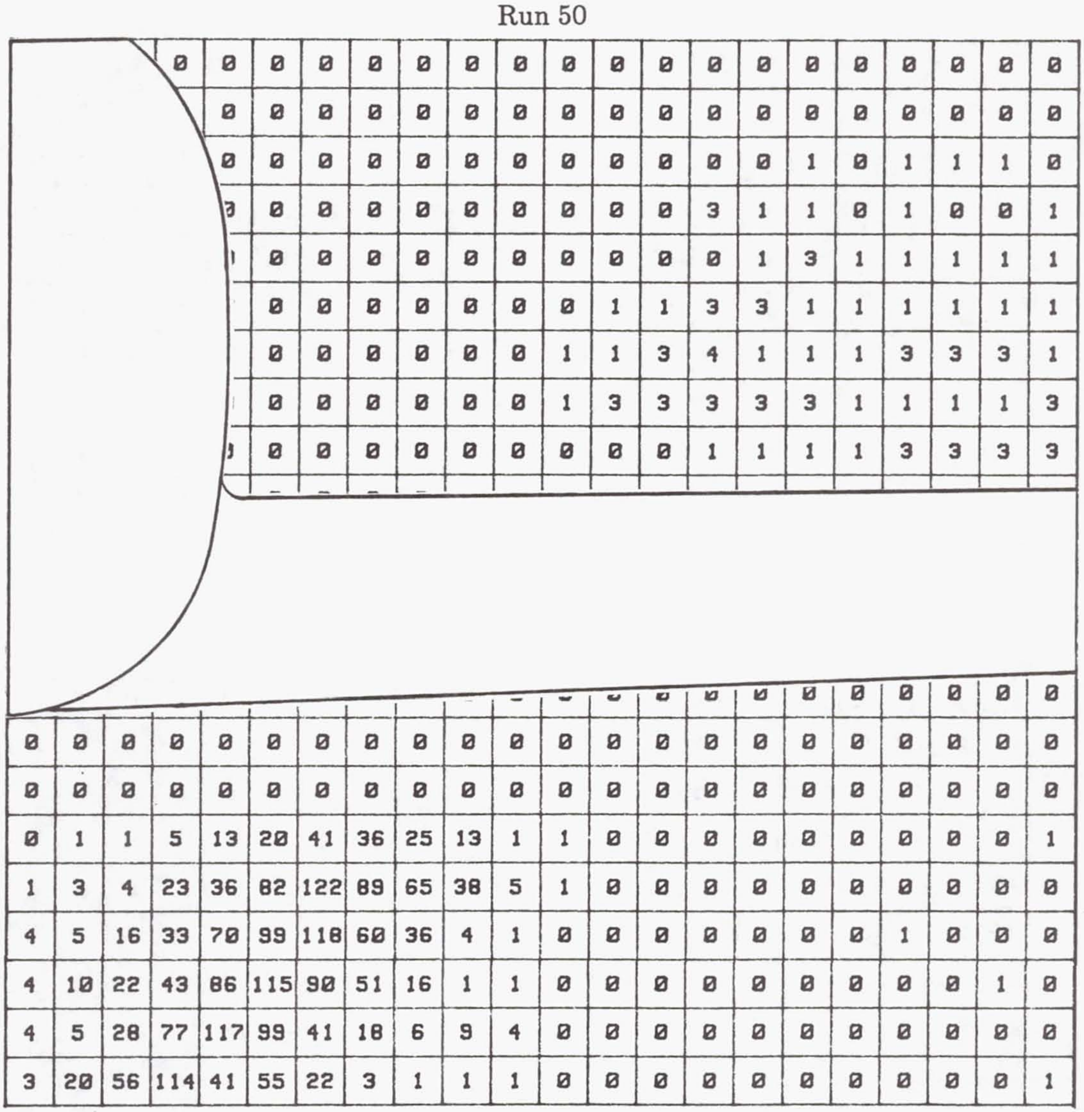


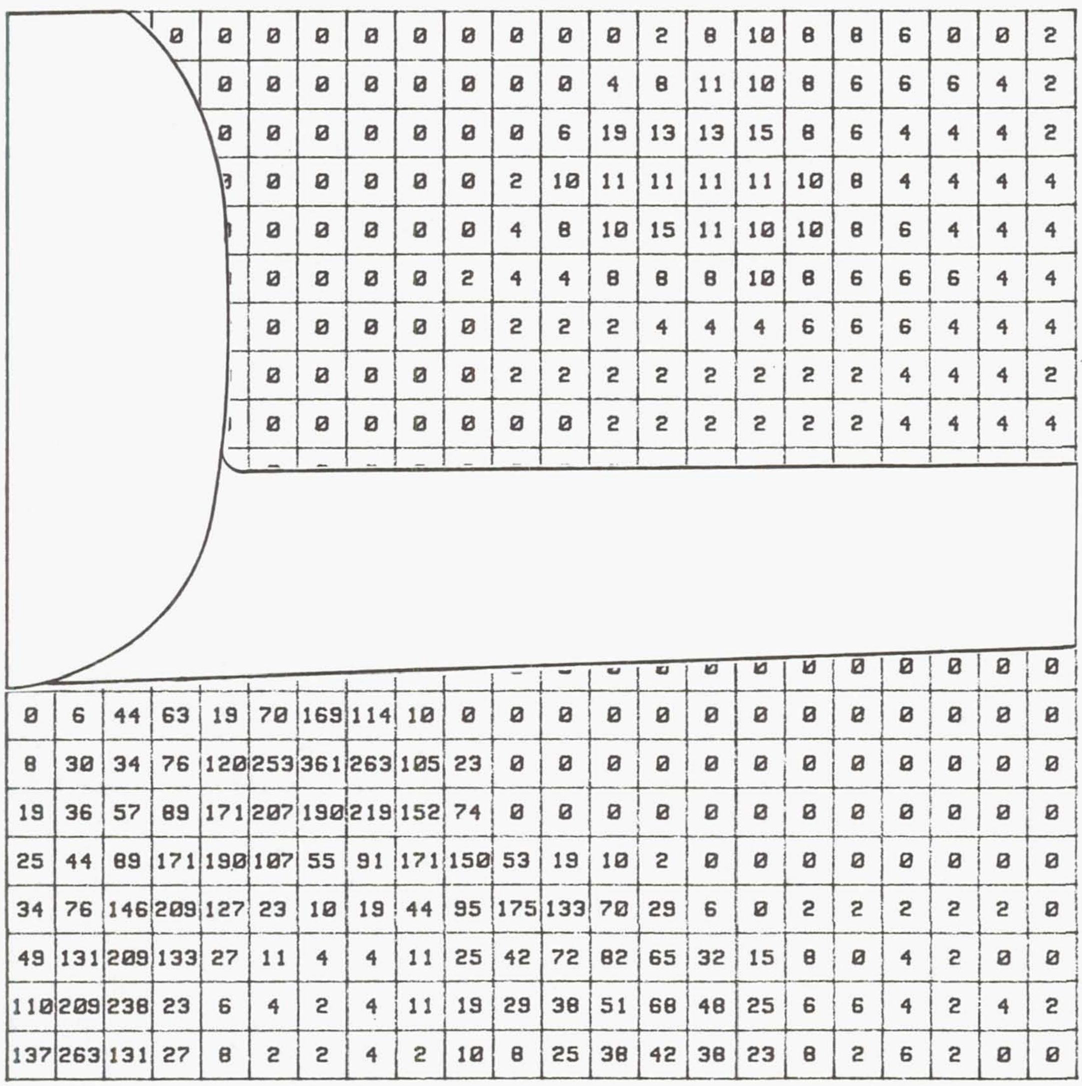
Speed = 40 fps   Load = 500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute × 10^2

Figure A4. Fuselage-installed test configuration with wing aft with 6.00 × 6 bias-ply tire.

Run 51



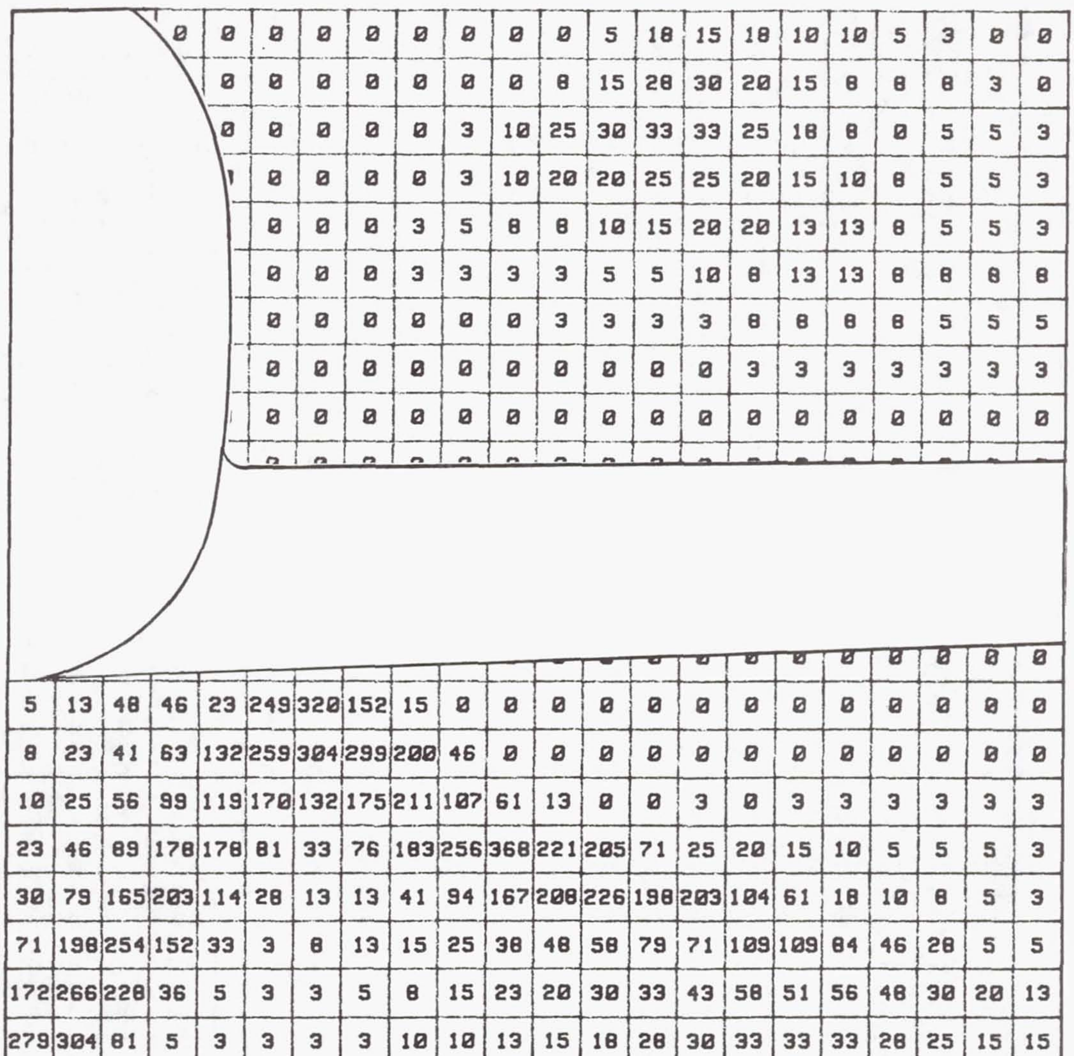
Speed = 60 fps   Load = 500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute $\times 10^2$

Figure A4. Continued.

Run 52



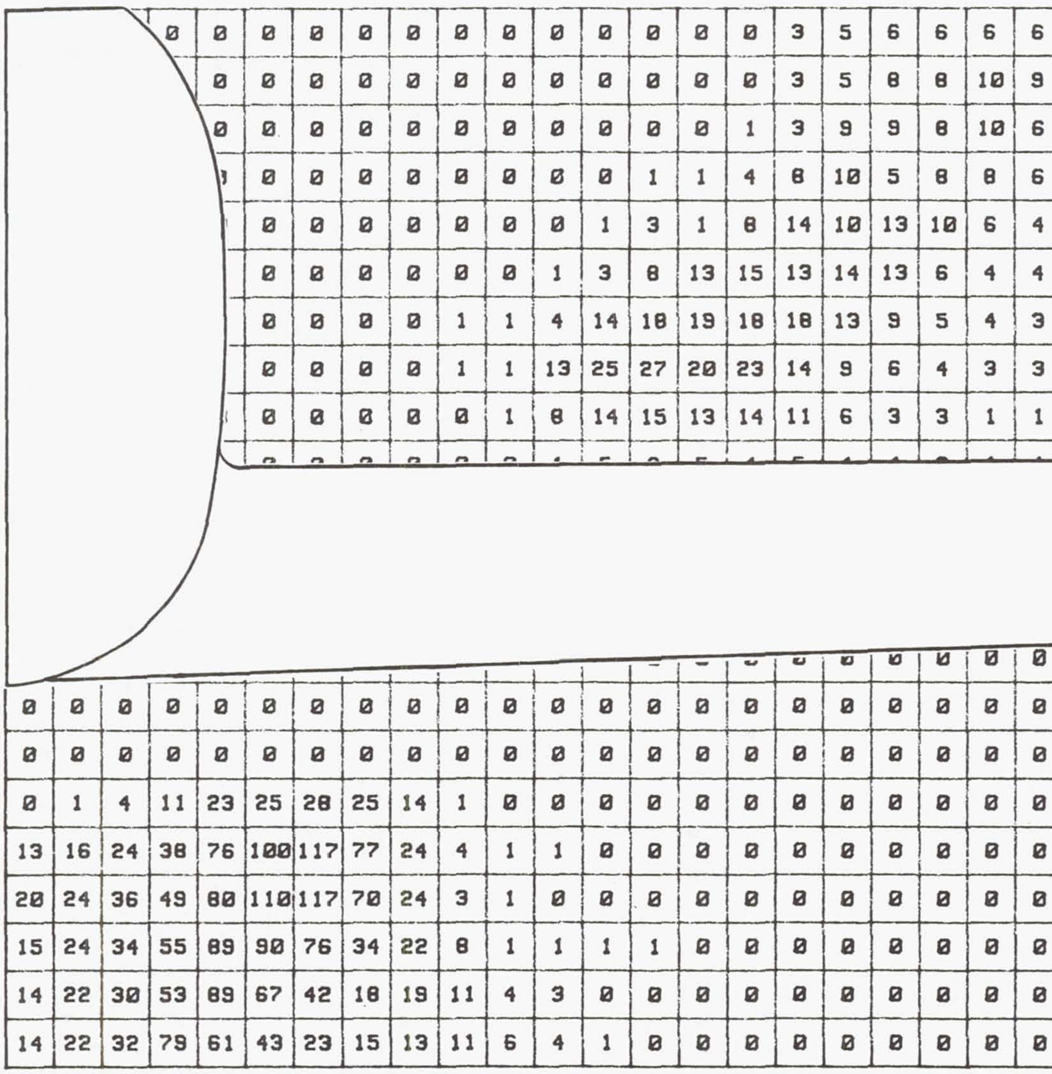
Speed = 80 fps   Load = 500 lb   Water depth = .625 in.   Tire pressure = 35 psi

Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A4. Continued.

Run 53



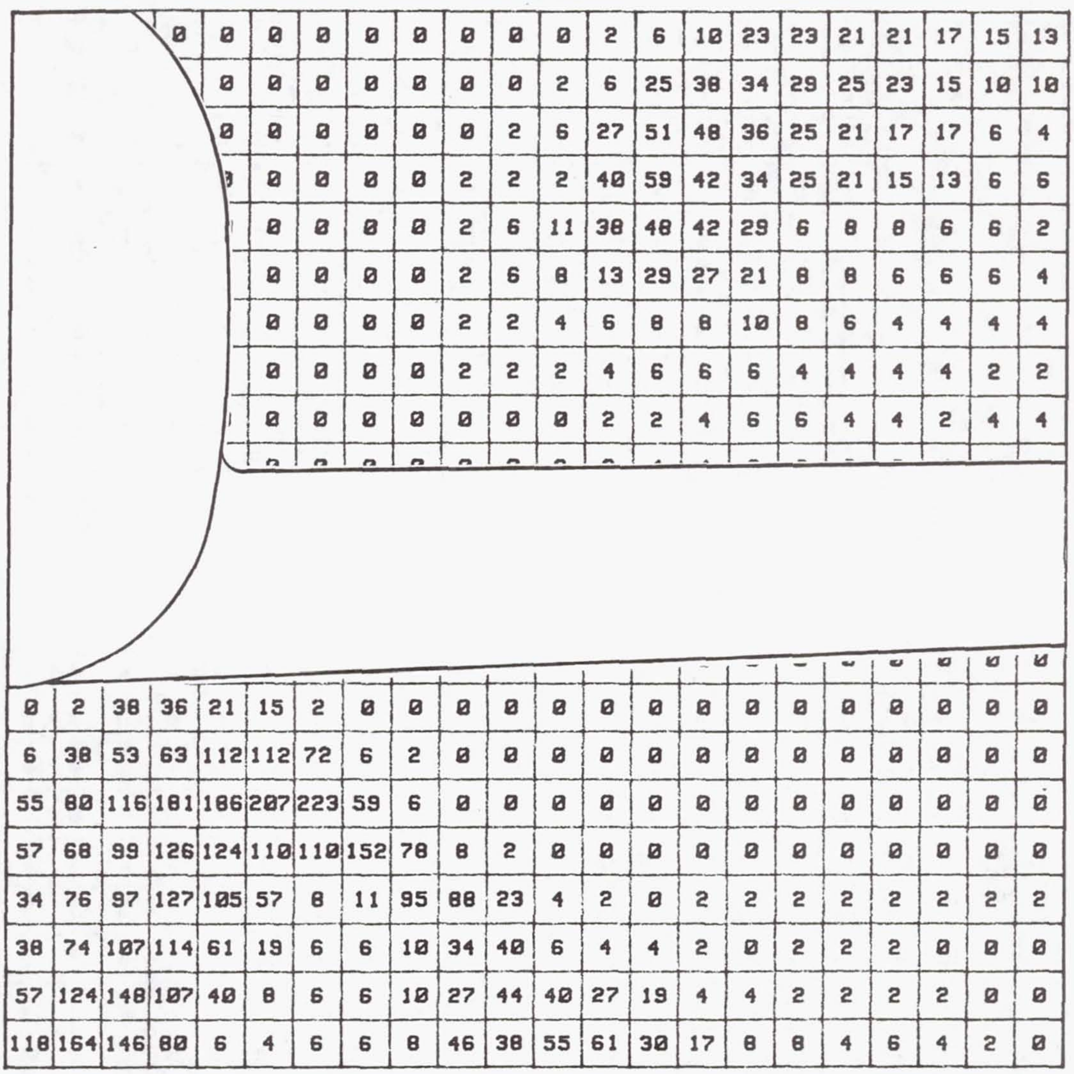
Speed = 40 fps Load = 2500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = 14 in. z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A4. Continued.

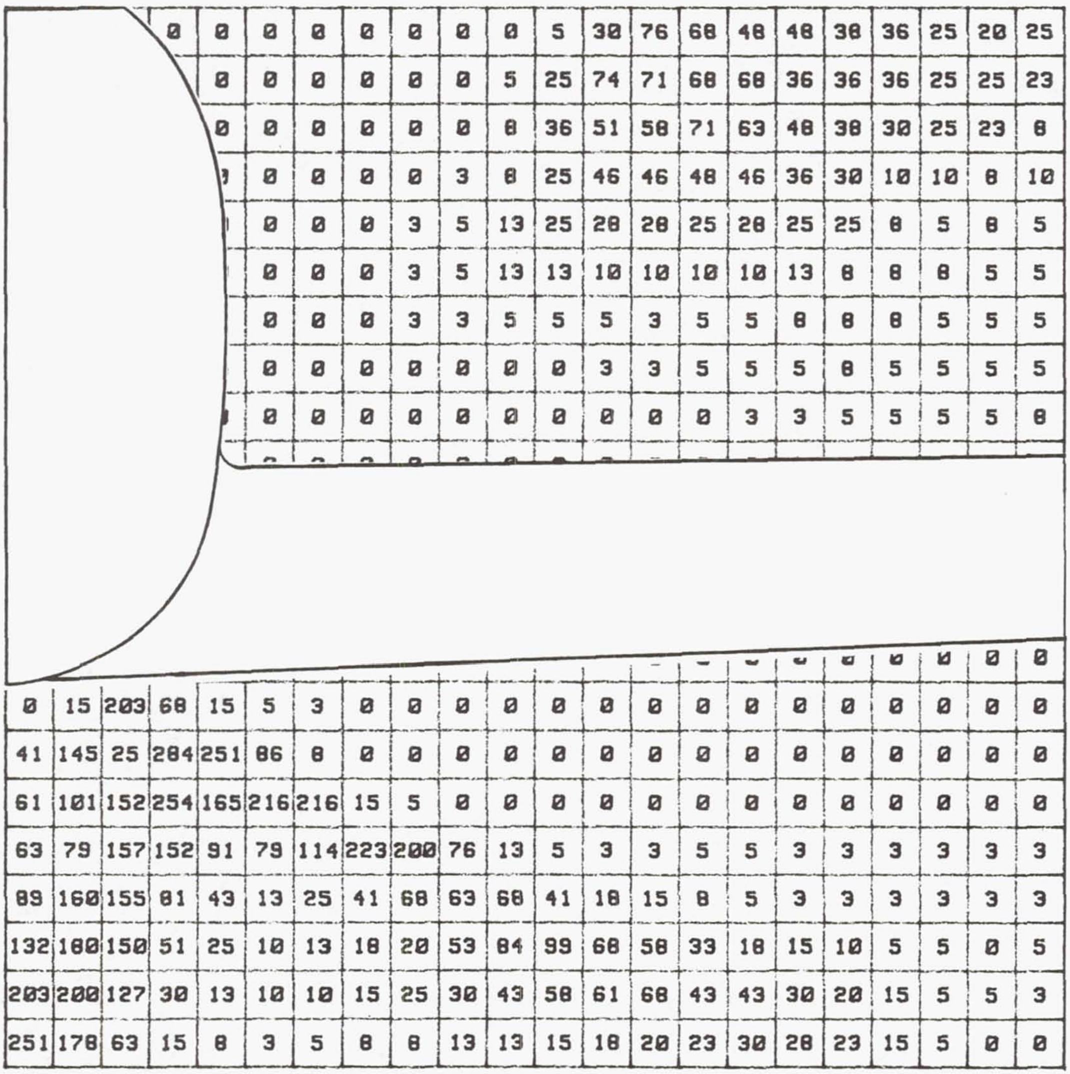
Run 54



Speed = 60 fps   Load = 2500 lb   Water depth = .625 in.   Tire pressure = 35 psi
Coordinates: x = 199 in.   y = 14 in.   z = 16 in.
Flow values are in gallons per minute x 10^2

Figure A4. Continued.

Run 55



Speed = 80 fps Load = 2500 lb Water depth = .625 in. Tire pressure = 35 psi

Coordinates: x = 199 in. y = 14 in. z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A4. Concluded.

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Run 56

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	1	1	3	3	1	3	1	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0	3	1	1	3	3	1	3	1	1	0	0	0	0
0	0	0	0	0	0	0	3	3	3	3	3	3	3	1	1	0	1	0	0	0	0
0	0	0	0	0	0	1	1	1	4	3	5	3	3	3	3	3	1	1	1	0	0
0	0	0	0	0	0	1	3	4	4	5	6	9	6	6	5	5	1	0	0	0	0
0	0	0	0	0	1	3	4	13	13	11	14	14	5	6	9	4	1	0	1	0	0
0	0	0	0	0	0	1	4	8	10	18	23	27	19	8	3	3	0	0	0	0	0
0	0	0	0	0	1	1	6	16	15	30	30	47	14	14	1	1	0	0	0	0	0
0	0	0	0	0	1	4	16	24	30	63	74	61	46	6	4	0	0	0	0	0	0
0	0	0	0	0	1	6	15	25	67	98	79	53	29	25	1	0	0	0	0	0	0
0	0	0	0	1	3	16	41	47	85	9	56	25	6	3	1	0	0	0	0	0	0
0	0	0	0	1	5	13	36	41	114	65	25	10	4	0	0	0	0	0	0	0	0
0	0	0	0	1	8	24	47	57	63	32	13	4	0	0	0	0	0	0	0	0	0
0	0	0	0	8	15	28	63	49	38	30	3	0	0	0	0	0	0	0	0	0	0
0	0	0	3	15	23	41	51	65	25	4	1	0	0	0	0	0	0	0	0	0	0
0	0	0	5	22	36	81	60	19	14	4	0	0	0	0	0	0	0	0	0	0	0

Speed = 40 fps   Tire deflection = 1 in.   Water depth = .625 in.
Tire pressure = 45 psi   Coordinates: x = 199 in.   y = 14 in.   z = 16 in.
Flow values are in gallons per minute $\times 10^2$

Figure A5. Tire-only test configuration with 26 × 6.6 bias-ply tire deflected to 1.0 in.

Run 57

0	0	0	0	0	0	0	2	2	4	4	6	6	8	8	19	10	6	4	2	0	0
0	0	0	0	0	0	0	2	2	4	6	8	11	23	19	15	11	10	6	2	0	0
0	0	0	0	0	2	0	2	4	4	6	8	21	30	29	34	29	10	10	4	2	0
0	0	0	0	0	0	2	2	4	8	15	15	34	40	53	57	68	34	17	8	2	2
0	0	0	0	0	2	2	2	8	17	25	30	36	74	76	82	38	19	10	4	2	0
0	0	0	0	0	2	2	2	8	19	40	46	97	95	110	76	38	19	10	6	2	2
0	0	0	0	0	0	2	4	8	21	34	53	78	86	82	55	23	8	8	4	4	2
0	0	0	0	0	2	4	8	19	29	40	61	76	76	49	27	13	6	4	4	4	2
0	0	0	0	0	2	6	15	23	38	53	57	76	53	21	19	8	6	2	2	2	2
0	0	0	0	0	2	6	21	30	44	53	70	57	30	19	10	8	6	4	4	2	2
0	0	0	0	2	4	6	19	38	48	51	55	38	19	11	6	4	4	2	2	2	2
0	0	0	2	4	6	10	34	55	57	57	32	27	6	2	2	2	2	0	0	0	0
0	0	0	2	4	8	23	40	59	51	38	29	11	2	2	2	2	2	2	2	0	0
0	0	0	2	11	21	38	59	72	40	27	11	10	4	4	2	2	0	0	2	0	0
0	0	2	4	11	36	57	65	46	23	13	6	2	2	2	2	0	0	0	0	0	0
0	0	2	6	21	44	88	55	36	19	8	2	2	0	0	0	0	0	0	0	0	0
0	2	6	21	38	78	82	38	19	11	2	2	2	0	0	0	0	0	0	0	0	0
0	2	10	34	76	110	59	30	8	2	2	2	2	2	0	0	0	0	0	0	0	0
2	4	19	65	118	105	53	15	2	2	2	2	0	0	0	0	0	0	0	0	0	0
4	11	34	118	143	72	29	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0
6	38	74	143	112	38	6	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
13	48	133	152	67	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Tire deflection =   1 in.   Water depth = .625 in.

Tire pressure = 45 psi   Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A5. Continued.

Run 58

0	0	0	3	3	3	3	8	8	18	23	41	51	76	96	104	84	56	41	8	5	3
0	0	0	3	5	5	8	10	23	28	30	43	51	68	89	63	53	36	25	10	3	0
0	0	0	3	3	3	8	10	18	25	33	46	56	68	51	51	51	30	18	5	3	0
3	3	3	3	3	5	5	8	10	25	38	51	51	48	51	43	30	25	8	8	5	0
3	3	3	3	5	5	5	13	25	25	38	51	48	51	51	38	25	8	5	3	3	3
3	3	3	3	5	5	10	18	28	41	41	46	41	30	25	15	10	8	8	5	3	0
3	3	3	3	3	8	5	25	33	51	48	46	36	25	13	10	8	8	8	3	3	3
3	3	3	3	3	8	23	33	48	46	51	41		13	8	5	5	5	3	3	0	0
3	3	3	3	8	20	28	46	48	51	41	25	10	10	8	8	8	10	5	5	3	0
3	3	5	8	30	30	46	58	46	46	25	18	10	8	5	5	5	5	5	3	3	0
3	5	8	10	25	41	51	36	51	36	20	8	8	5	5	5	0	3	3	3	0	0
3	3	10	28	33	46	58	63	43	25	8	5	3	3	5	5	5	5	3	3	3	0
3	8	18	30	51	76	71	48	28	8	5	3	3	3	3	5	5	3	3	3	0	0
3	8	15	41	71	74	63	41	13	8	8	3	3	5	5	5	5	3	0	0	0	0
5	15	33	58	76	71	51	25	10	3	0	3	3	3	3	5	3	3	0	0	0	0
8	23	48	81	79	79	41	13	5	3	0	0	3	3	3	5	3	0	0	0	0	0
15	30	61	114	99	51	25	10	3	0	3	5	5	0	0	0	0	0	0	0	0	0
25	28	91	127	66	43	8	3	3	0	3	0	3	0	0	0	3	0	0	0	0	0
30	76	127	134	61	20	5	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0
51	109	155	124	28	5	3	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0
76	152	165	79	8	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
104	190	162	48	8	8	3	3	0	3	3	0	0	3	0	0	0	0	0	0	0	0

Speed = 80 fps   Tire deflection = 1 in.   Water depth = .625 in.

Tire pressure = 45 psi   Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A5. Continued.

Run 59

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	0	3
0	0	0	0	0	0	0	0	3	3	3	0	0	0	0	0	0	3	0	0	0	0
0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	3	5	0	3	3	0	0
0	0	0	0	0	0	0	0	3	3	3	5	10	8	13	15	20	18	15	8	5	0
0	0	0	0	0	0	0	0	3	3	5	10	18	25	41	56	68	71	46	30	8	5
0	0	0	0	0	0	0	3	3	5	13	28	36	68	81	101	109	99	86	46	10	0
0	0	0	0	0	0	3	3	5	13	30	38	53	74	109	132	122	112	61	46	5	0
0	0	0	0	0	0	3	3	5	15	23	30	51	76	119	129	99	89	56	28	3	0
0	0	0	0	0	3	3	5	8	13	25	38	51	71	84	86	94	63	46	20	3	0
0	0	0	0	0	3	5	5	8	20	28	38	43	48	71	68	53	38	30	10	5	0

Speed = 80 fps   Tire deflection = 1 in.   Water depth = .625 in.

Tire pressure = 45 psi   Coordinates: x = 199 in.   y = 14 in.   z = 46.5 in.

Flow values are in gallons per minute × 10^2

Figure A5. Concluded.

Run 60

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
0	0	0	0	0	0	0	0	0	1	1	1	3	3	1	3	1	3	1	0	0	0
0	0	0	0	0	0	0	0	0	0	1	1	1	4	4	4	4	3	1	3	0	0
0	0	0	0	0	0	0	0	0	1	1	3	5	5	6	4	3	3	1	1	0	1
0	0	0	0	0	0	0	0	0	3	4	3	5	4	9	3	3	3	1	1	1	0
0	0	0	0	0	0	0	1	1	3	5	8	9	6	5	4	4	1	1	0	1	0
0	0	0	0	0	0	1	1	1	4	10	6	13	8	6	6	3	1	3	3	0	1
0	0	0	0	0	0	0	0	6	9	13	13	14	10	8	5	3	3	0	0	0	0
0	0	0	0	0	1	1	3	4	11	14	24	14	14	11	8	4	1	1	1	0	0
0	0	0	0	0	0	0	1	3	8	14	20	15	16	16	10	4	4	3	1	0	0
0	0	0	0	0	1	1	3	11	15	25	27	24	22	13	11	3	3	3	1	0	0
0	0	0	0	0	1	3	5	10	24	25	27	38	43	10	18	1	0	0	0	0	0
0	0	0	0	0	0	1	4	11	19	34	51	60	43	37	5	1	0	0	0	0	0
0	0	0	0	0	0	3	6	18	61	90	81	104	48	11	1	1	0	0	0	0	0
0	0	0	0	1	1	3	14	29	60	61	85	44	16	3	1	0	0	0	0	0	0
0	0	0	0	0	3	8	15	27	57	58	53	37	9	1	1	0	0	0	0	0	0
0	0	0	1	1	4	10	20	38	44	42	37	20	3	1	0	0	0	0	0	0	0
0	0	0	1	1	3	15	32	46	44	36	24	9	3	3	0	0	0	0	0	0	0
0	0	0	1	3	5	29	36	36	39	24	13	4	0	1	0	0	0	0	0	0	0

Speed = 40 fps Tire deflection = 1.1 in. Water depth = .625 in.
Tire pressure = 45 psi Coordinates: x = 199 in. y = 14 in. z = 16 in.
Flow values are in gallons per minute x 10^2

Figure A6. Tire-only test configuration with 26 × 6.6 radial-ply tire deflected to 1.1 in.

Run 61

0	0	0	0	0	0	0	0	0	0	2	4	4	6	10	8	8	6	2	0	0	0
0	0	0	0	0	0	0	0	0	2	4	2	6	10	10	8	8	11	6	0	0	0
0	0	0	0	0	0	0	0	0	4	4	6	6	8	11	10	10	10	4	6	0	0
0	0	0	0	0	0	0	0	2	6	10	17	19	21	32	19	29	19	15	17	4	4
0	0	0	0	0	0	0	2	4	6	6	23	34	36	30	38	30	25	19	8	4	4
0	0	0	0	0	0	0	2	4	8	19	27	36	30	44	38	36	27	23	21	4	2
0	0	0	0	0	2	2	2	6	11	21	30	38	51	51	38	34	23	17	13	6	0
0	0	0	0	0	0	2	2	2	8	23	57	59	57	53	38	30	21	13	11	6	4
0	0	0	0	0	2	2	4	6	21	36	65	57	55	42	34	29	23	8	6	6	2
0	0	0	0	0	0	2	4	10	25	42	57	61	57	36	34	23	19	6	4	4	0
0	0	0	0	0	2	4	6	11	30	42	57	68	53	36	30	19	8	4	4	4	0
0	0	0	0	2	2	4	8	17	21	44	57	51	38	32	19	6	6	0	4	2	0
0	0	0	0	2	2	4	15	23	38	51	57	40	32	23	19	6	6	4	2	0	0
0	0	0	0	2	2	6	17	36	42	51	38	38	38	13	6	6	4	4	4	0	0
0	0	0	0	2	6	15	23	38	65	57	42	34	23	8	0	4	4	4	2	0	0
0	0	0	2	2	6	19	34	61	51	42	34	19	6	4	2	2	2	4	0	2	0
0	0	2	2	4	15	36	57	70	53	29	19	8	6	4	4	4	2	2	0	2	0
0	0	2	4	6	25	51	67	67	36	21	15	8	6	6	2	4	4	2	0	0	0
0	0	2	4	48	76	89	63	23	4	6	2	2	2	0	0	0	0	0	0	0	0
2	2	4	8	42	76	103	63	23	8	8	2	4	2	0	2	2	0	2	2	0	0
2	2	10	27	72	124	107	34	6	8	2	2	2	0	2	2	0	0	0	0	0	0
0	2	8	44	124	133	40	8	4	4	2	0	2	2	0	0	2	2	2	0	0	0

Speed = 60 fps   Tire deflection = 1.1 in.   Water depth = .625 in.

Tire pressure = 45 psi   Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A6. Continued.

Run 62

0	0	0	0	0	0	0	3	3	5	8	10	13	38	38	63	84	81	76	56	28	28
15	0	0	0	0	0	0	0	3	3	5	8	10	18	51	81	101	89	71	56	30	23
8	0	0	0	0	0	0	0	3	3	3	8	15	28	56	81	84	84	63	51	41	51
13	0	0	0	0	0	0	0	0	3	8	10	25	38	53	84	61	71	56	48	25	8
5	0	0	0	0	0	0	3	3	5	8	20	25	51	63	96	53	53	33	25	30	10
0	0	0	0	0	0	3	3	3	8	13	23	30	41	56	58	43	43	43	28	8	8
3	0	0	0	0	3	3	3	3	5	10	23	41	61	58	53	46	41	30	25	10	5
3	0	0	0	0	0	3	5	5	10	20	33	46	58	68	41	43	41	25	10	8	3
3	0	0	0	0	3	3	5	10	20	28	48	66	68	51	46	46	25	20	10	3	3
0	0	0	0	3	3	3	5	13	23	33	56	61	48	41	43	25	18	10	5	5	3
0	0	0	3	3	5	8	18	23	28	56	58	63	56	38	33	25	10	5	5	5	0
3	0	3	3	3	8	8	13	28	51	74	66	53	38	30	10	8	8	5	5	3	0
0	3	3	3	3	5	8	15	38	61	76	71	46	30	13	13	8	5	5	3	0	0
3	3	3	3	5	8	15	38	71	86	79	51	25	18	10	5	5	5	3	3	3	3
3	3	3	3	5	15	28	61	84	96	61	25	20	10	8	8	10	5	3	3	3	3
3	3	3	5	13	13	53	84	104	66	25	15	13	8	8	5	5	5	5	5	5	5
3	3	3	8	18	46	99	114	86	41	15	10	8	8	5	5	3	3	3	3	3	3
3	3	3	13	33	68	132	127	56	8	8	8	5	3	5	5	5	5	5	3	3	3
3	5	10	25	61	117	139	84	25	5	3	3	5	5	5	5	3	3	5	5	5	5
5	10	13	30	96	185	150	51	13	10	5	5	5	5	3	3	8	5	5	3	3	3
3	10	10	63	160	226	89	25	10	5	5	5	5	5	5	3	8	5	3	3	3	3
3	13	30	109	261	178	25	8	3	3	3	3	3	3	5	3	3	5	3	3	3	0

Speed = 80 fps   Tire deflection = 1.1 in.   Water depth = .625 in.
Tire pressure = 45 psi   Coordinates: x = 199 in.   y = 14 in.   z = 16 in.
Flow values are in gallons per minute x 10^2

Figure A6. Continued.

Run 63

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	3	3	3	5	3	5	8	3	3	3	3	0	0
0	0	0	0	0	0	0	0	3	3	5	13	15	13	15	13	10	10	8	5	0	0
0	0	0	0	0	0	0	3	3	5	8	15	23	33	41	25	25	28	28	15	0	0
0	0	0	0	0	0	3	3	3	5	10	15	41	46	48	56	46	30	13	5	5	0
0	0	0	0	0	0	3	3	3	5	20	20	30	46	56	84	66	56	41	30	10	3
0	0	0	0	0	0	0	3	5	8	13	23	36	66	94	94	71	56	38	28	23	8

Speed = 80 fps Tire deflection = 1.1 in. Water depth = .625 in.

Tire pressure = 45 psi Coordinates: x = 199 in. y = 14 in. z = 46.5 in.

Flow values are in gallons per minute $\times 10^2$

Figure A6. Concluded.

Run 64

0	0	0	0	0	0	0	2	2	6	10	10	17	19	23	19	19	17	13	6	2	0
0	0	0	0	0	0	0	2	4	8	10	15	19	19	27	25	23	15	10	4	4	0
0	0	0	0	0	0	0	2	4	6	10	19	19	36	38	21	19	15	13	8	6	0
0	0	0	0	0	0	0	2	6	11	15	25	38	38	30	19	21	19	10	6	2	0
0	0	0	0	0	0	2	4	6	15	27	34	36	36	29	19	17	13	8	6	2	0
0	0	0	0	0	0	2	4	10	19	27	34	44	38	23	19	17	8	6	4	2	0
0	0	0	0	0	0	2	4	11	17	32	51	57	36	19	19	15	13	8	4	0	0
0	0	0	0	0	0	2	8	11	23	38	42	53	36	17	6	6	6	2	4	0	0
0	0	0	0	0	2	4	8	13	23	40	48	48	36	2	6	6	6	2	2	0	0
0	0	0	0	0	0	2	8	19	29	48	55	38	17	6	4	2	2	0	0	0	0
0	0	0	0	0	2	4	8	11	32	40	53	34	23	13	6	4	2	2	0	0	0
0	0	0	0	0	2	4	11	19	44	48	36	21	17	10	2	2	0	0	0	0	0
0	0	0	0	0	2	4	19	29	40	48	32	19	11	6	4	0	0	0	0	0	0
0	0	0	0	0	4	15	21	44	38	44	25	17	15	2	2	0	0	0	0	0	0
0	0	0	0	2	6	19	38	49	42	38	19	8	6	4	0	0	0	0	0	0	0
0	0	0	0	4	8	29	36	46	34	23	10	6	2	0	0	0	0	0	0	0	0
0	0	0	2	11	19	51	59	80	25	17	6	2	0	0	0	0	0	0	0	0	0
0	0	0	2	21	44	63	76	34	13	8	2	2	0	0	0	0	0	0	0	0	0
0	0	4	8	30	101	76	40	8	4	0	0	0	0	0	0	0	0	0	0	0	0
2	6	8	34	84	110	70	23	4	0	0	0	0	0	0	0	0	0	0	0	0	0
2	6	17	74	120	91	29	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0
2	10	42	116	105	44	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Speed = 60 fps   Tire deflection = 1.9 in.   Water depth = .625 in.

Tire pressure = 45 psi   Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute x 10^2

Figure A7. Tire-only test configuration with 26×6.6 radial-ply tire deflected to 1.9 in.

Run 65

0	0	2	2	4	4	6	10	13	15	21	30	36	55	44	40	40	21	23	13	8	4
0	2	2	2	4	6	8	8	13	19	29	44	49	61	59	48	36	34	19	21	2	2
2	2	4	6	8	8	13	15	21	34	46	48	57	61	40	27	19	11	6	4	2	2
2	2	2	2	2	6	8	8	17	23	30	38	51	57	51	38	23	17	11	6	4	2
4	4	4	6	8	8	10	15	19	21	30	38	42	42	34	25	19	10	11	6	4	0
4	6	6	6	6	6	13	13	17	23	30	36	36	36	27	21	15	8	6	4	4	0
6	6	6	8	8	13	15	19	21	25	34	34	36	30	19	15	11	10	6	6	4	0
6	6	6	6	8	10	15	21	29	29	38	34	32	23	19	13	8	8	4	0	2	0
6	6	6	6	8	11	17	23	30	34	38	34	23	19	10	6	6	6	4	0	2	0
6	6	6	10	15	19	32	32	34	38	32	21	38	6	6	4	4	4	2	2	2	2
4	4	6	10	10	17	21	30	38	38	30	29	17	10	8	8	4	4	2	2	0	0
2	2	6	8	13	21	32	36	30	34	21	19	15	8	8	6	6	4	4	4	4	2
2	6	6	13	17	29	30	40	38	36	19	15	6	4	4	4	2	2	2	2	2	2
2	4	6	15	27	38	42	48	40	25	17	10	2	2	2	0	0	0	0	0	0	0
2	4	10	17	38	38	46	44	34	13	10	4	4	2	0	2	2	2	2	2	0	0
4	11	23	34	40	55	55	48	32	13	4	2	0	0	0	0	2	2	0	0	2	0
2	10	8	38	57	59	46	29	13	8	2	2	0	0	2	2	2	0	0	2	0	0
6	6	38	49	63	53	38	19	6	4	0	2	0	0	0	0	0	2	2	0	0	0
10	25	53	65	74	57	21	6	4	0	0	0	2	0	0	0	0	2	0	0	0	0
15	36	57	82	72	34	17	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0
21	57	86	95	51	25	8	2	2	2	0	0	0	2	0	0	0	0	0	0	0	0
38	76	110	84	42	4	2	2	0	0	0	0	0	2	0	0	2	0	0	0	0	0

Speed = 60 fps   Tire deflection = 1.8 in.   Water depth = .625 in.

Tire pressure = 45 psi   Coordinates: x = 199 in.   y = 14 in.   z = 16 in.

Flow values are in gallons per minute × 10^2

Figure A8. Tire-only test configuration with 26 × 6.6 bias-ply tire deflected to 1.8 in.

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Run 66

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0
0	0	0	0	0	0	0	0	0	2	0	0	2	2	0	2	0	2	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	2	2	2	2	4	2	2	0	0	0	0	0
0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	0	0	0	0	0
0	0	0	0	0	0	0	0	2	2	2	2	2	0	2	2	2	2	0	0	0	0
0	0	0	0	0	0	0	0	2	2	4	4	4	4	4	4	4	4	2	0	0	0
0	0	0	0	0	2	2	2	4	4	4	4	8	8	8	11	11	8	6	2	0	0
0	0	2	2	0	2	2	2	4	4	6	6	8	17	21	23	21	17	21	19	8	4
0	0	0	0	2	2	2	2	2	4	6	15	17	21	23	36	42	32	29	19	8	4
0	0	0	0	2	0	2	2	2	4	6	19	23	29	36	40	53	48	38	27	8	8
0	0	0	2	2	2	2	2	2	2	15	21	27	23	34	42	44	42	38	23	6	6

Speed = 60 fps   Tire deflection = 1.8 in.   Water depth = .625 in.

Tire pressure = 45 psi   Coordinates: x = 199 in.   y = 14 in.   z = 46.5 in.

Flow values are in gallons per minute $\times 10^2$

Figure A8. Concluded.

Report Documentation Page

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15. Supplementary Notes

16. Abstract

An experimental investigation was conducted at the NASA Langley Research Center to measure the flow rate and trajectory of water spray generated by an aircraft tire operating on a flooded runway. Tests were conducted in the Hydrodynamics Research Facility and made use of a partial airframe and a nose tire from a general aviation aircraft. Nose tires from a commercial transport aircraft were also used. The effects of forward speed, tire load, and water depth on water spray patterns were evaluated by measuring the amount and location of water captured by an array of tubes mounted behind the test tire. Water ejected from the side of the tire footprint had the most significant potential for ingestion into engine inlets. A lateral wake created on the water surface by the rolling tire can dominate the shape of the spray pattern as the distance aft of the tire is increased. Forward speed increased flow rates and moved the spray pattern inboard. Increased tire load caused the spray to become less dense. Near the tire, increased water depths caused flow rates to increase. Tests using a fuselage and partial wing along with the nose gear showed that for certain configurations, wing aerodynamics can cause a concentration of spray above the wing. Tests with nose tires from a commercial transport aircraft showed virtually identical spray-pattern and flow-rate behavior when comparing tires of bias-ply versus radial-ply construction.

17. Key Words (Suggested by Authors(s))	18. Distribution Statement
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