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WE PUT WATER IN ITS PLACE

How To Calculate Drainage

Doctor Drainage

NDS

How to Calculate Drainage

Calculating drainage (also called storm water runoff) may sound difficult, but it is actually quick and easy to do. By following the steps outlined in this article, you will be able to determine the amount of water draining from your property and ways that this water can be efficiently stored. The steps below include examples that show exactly what you need to do. After following the "Now You Try" steps, you will be able to personalize the steps below and apply them to your individual home.

The equations and methods shown have been simplified. In all cases, the results will overestimate the runoff and storage requirements. Please check with your public municipality before beginning any grading or drainage work on your property because they might use different values, different methods, and may require permits or drainage calculations that are reviewed and signed by a licensed civil engineer.

Runoff Equation

In most cases, storm water runoff can be calculated using the Rational Method. This method can be used for all drainage areas less than 200 acres. For drainage areas greater than 200 acres, other methods can be used, or the drainage area can be divided into zones less than 200 acres.

The Rational Method equation is: Q = C x I x A where:

Q = Storm Water Runoff (in cubic feet per second)
C = Coefficient of Runoff
I = Rainfall Intensity (in inches per hour)
A = Area of Drainage Zone (in acres)

The equation above can be modified to give you runoff in gallons per minute.
The modified equation is: Q = (C x I x A) / 96.23 where:

Q = Storm Water Runoff (in gallons per minute, gpm)
C = Coefficient of Runoff
I = Rainfall Intensity (in inches per hour)
A = Area of Drainage Zone (in square feet)

Calculating runoff from your property can be done in three steps;

1) Calculate the runoff

2) Calculate the volume of water to be stored

3) Determine how to store the water

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Step 1. Calculate the Runoff – "Q"

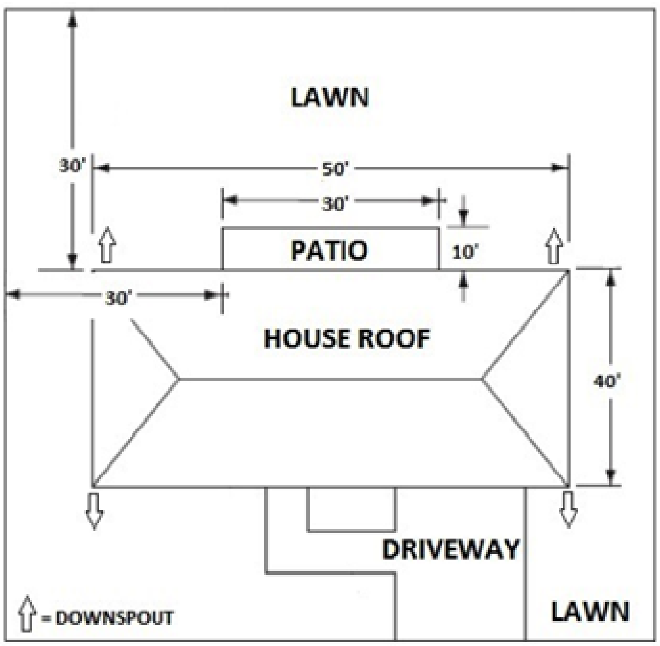
Determine the Area – "A"

Before solving for other variables in the rational method equation, it is best to first determine the size of the area where the runoff is coming from.

There are a few things that you will need to calculate the runoff from your home. Here is a list of materials to gather before you begin:

- Paper
- Pencil and eraser
- Highlighter, crayons, colored pencils, or markers
- Calculator
- Tape Measure
- Tables and Maps from this article

The first step is to determine the area (in square feet) where the runoff is coming from. The picture below shows a residential lot with a house, driveway, and lawn. The four arrows at the corners of the house represent the location of downspouts. It is much easier to determine the runoff if we first draw a simplified sketch of the property. This sketch should include the house, walkways, driveways, patios, pool, lawn, flower beds, and any other major landscape features. We will use this to keep track of each drainage area.



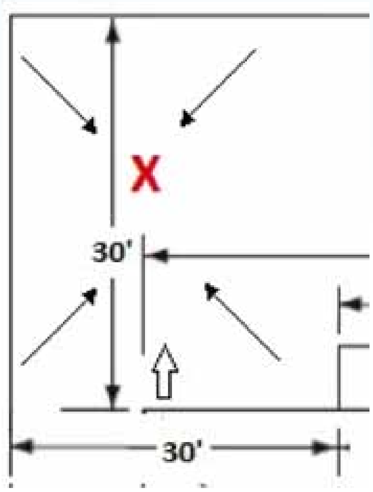
Now You Try : Using your tape measure, paper, and pencil, draw a simple sketch of your property. Make sure to include the features listed above. Be sure to include all dimensions on your drawing. These dimensions will be used in future calculations.

Step 1. (continued)

Now that we have a sketch of the home, we need to determine where the water is draining. This can be done by casual inspection. Drawing simple arrows that show the direction of the flow will help determine the drainage zones. The arrows need to go from where the water is originating to where the water is draining. Each location where the water is draining is a separate drainage zone.

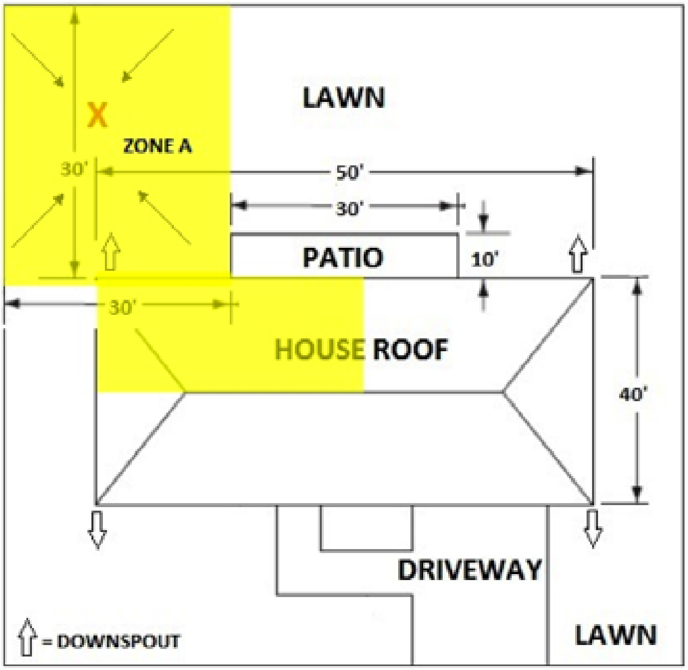
The "X" in the picture on the left represents a low spot in the backyard.

Now You Try: Draw drainage arrows on your sketch.



We can now determine the drainage zones. Each area where the arrows point to is a separate drainage zone. Multiple parts of your property may drain to a single drainage zone. In our example property, the back-left portion of the roof and the back-left portion of the lawn drain to "X". Labeling and coloring each drainage zone helps keep everything clear. The picture below shows drainage "Zone A". Notice that everything that drains to this zone is colored yellow.

Now You Try: Label and color each of your drainage zones.



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Step 1. (continued)

Now that we know where the water will drain to, we can begin to calculate how much water will run off to each drainage zone. First we will divide the roof into drainage areas. This house has four downspouts, one at each corner of the house, that equally drain the roof runoff. This house is 2000 square feet (50' x 40'). Each downspout will drain approximately 500 square feet (2000 sf / 4) of roof runoff. The back-left portion of the lawn is also included in drainage Zone A. This portion of the lawn is 900 square feet (30' x 30'). The runoff area from the roof and the lawn do not get combined into one total square footage. We need to keep these separate for now because the percentage of water that will drain from the roof differs from the percentage of water that will drain from the grass. Multiple portions of the roof that drain to the same drainage zone can be combined into one total roof square footage. After determining the total surface area for each surface draining to each zone, begin a table to keep track of the runoff. A table like the one shown below can be used.

Drainage Table

Drainage Zone	C		I (in. / hr)	A (sf)		Q (gpm)
Zone A				Roof	500	
Zone A				Lawn	900	

Now You Try: Look at your property. Find the square footage for each surface type draining to each drainage zone. Pay special attention to the roof and downspouts. Measure, or approximate, the square footage for each section of roof. If multiple sections drain to a single downspout, find the area of each section individually and then combine them into one area. Many houses do not have rain gutters installed. The portion of this roof that drains to each drainage zone needs to be accounted for. Note on your sketch the total square footage that drains to each zone for each surface type.

Step 1. (continued)

Determine the Coefficient of Runoff – "C"

Now that we know the area and surface material for everything contributing to each drainage zone, we can move on to the next variable in our drainage equation.

What is the Coefficient of Runoff? The Coefficient of Runoff, C, is the average percentage of water that runs off of a given surface material. A higher percentage of water that falls on concrete will run off than water that falls onto grass or sand. The Coefficient of Runoff is equal to the Runoff / Rainfall, expressed as a decimal. A table for the average Coefficient of Runoffs is shown below.

Coefficient of Runoff (C)= Runoff / Rainfall			
Soil Texture	**C**	**Soil Texture**	**C**
Concrete, Asphalt, Roof	1.00	Loam – Bare	0.60
Gravel – Compact	0.70	Loam – Light Vegetation	0.45
Clay – Bare	0.75	Loam – Dense Vegetation	0.35
Clay – Light Vegetation	0.60	Sand – Bare	0.50
Clay – Dense Vegetation	0.50	Sand – Light Vegetation	0.40
Gravel – Bare	0.65	Sand – Dense Vegetation	0.30
Gravel – Light Vegetation	0.50	Grass Area	0.35
Gravel – Dense Vegetation	0.40		

In our example property, the runoff that is draining to Zone A is coming from both a roof and a grass area. The "C" value for roof runoff is 1.00, and the "C" for grass is 0.35. Runoff often passes from one surface material to another on its way to the drainage point. We will show how to handle this in the Calculate the Runoff – "Q" a little later on. These values can be added to our Drainage Table:

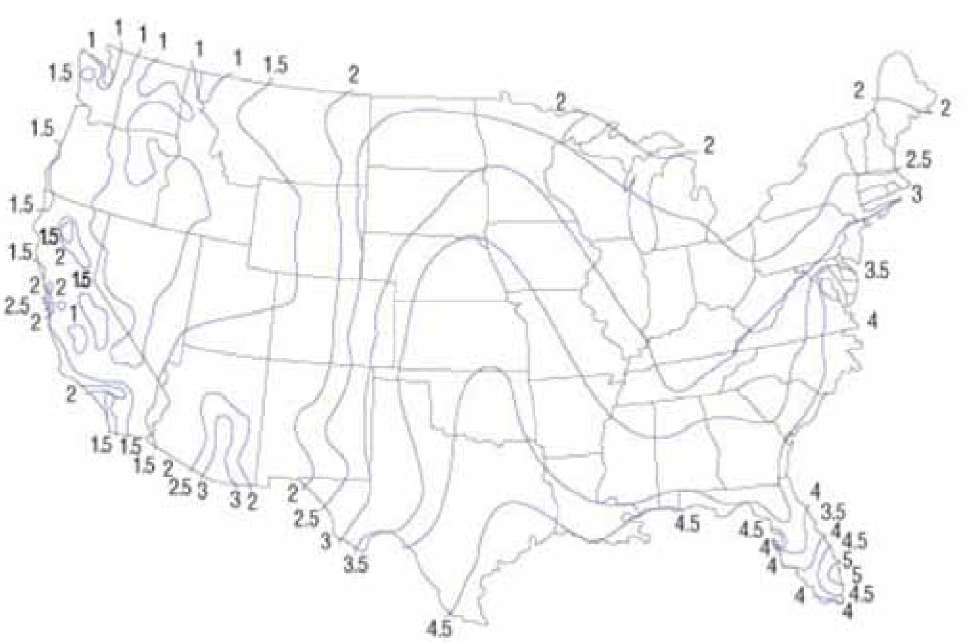
Drainage Table						
Drainage Zone	C		I (in. / hr)	A (sf)		Q (gpm)
Zone A	Roof	1.00		Roof	500	
Zone A	Lawn	0.35		Lawn	900	

Now You Try: Using the Coefficient of Runoff table above, fill in the "C" portion of your Drainage Table. Write in the surface material type and the corresponding "C" value for each area contributing to each drainage zone.

Step 1. (continued)

Determine the Rainfall Intensity – "I"

Each portion of the country experiences different amounts of rainfall. As I mentioned in the opening to this guide, your municipality may require you to use a different rainfall intensity value when determining your runoff. The map included here is a generalized map for a 100-year storm event for the United States. The numbers on the map represent the amount of rain that would fall in 1 hour for a storm that will come (on average) once every 100 years.



To use this map, find your location on the map and follow the line to the perimeter of the map that shows your expected rainfall. If your location falls between two line, take the average of the rainfalls. Our sample property is in Las Vegas, NV. The expected rainfall in the 100-year storm in Las Vegas, NV is 1.5 inches per hour. We now record this number in our Drainage Table.:

Drainage Table							
Drainage Zone	C		I (in. / hr)	A (sf)		Q (gpm)
Zone A	Roof	1.00	1.5	Roof	500	
Zone A	Lawn	0.35	1.5	Lawn	900	

Now You Try: Using the 100-year storm map above, find your location and expected storm amount. Record this value on you Drainage Table.

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Step 1. (continued)

Calculate the Runoff – "Q"

Now that we have all the variables filled into our Drainage Table, we are ready to calculate our runoff, Q. To do this, we simply multiply across each row. The runoff, Q, for the roof area in drainage Zone A is: (1.00 x 1.5 x 500) / 96.23 = 7.79 gallons per minute. The runoff for the grass portion of drainage Zone A is: (0.35 x 1.5 x 900) / 96.23 = 4.91 gpm. Notice that even though the grass area is nearly 2X that of the roof, the roof runoff is nearly 2X that of the grass area. This is due to the fact that the percentage of water that runs off of the roof is much higher than the percentage of water that runs off the grass. Following this procedure, we calculate the runoff for each area contributing to each drainage zone. Once we have the runoff for each area, we can combine all of the runoff that contributes to each zone, i.e. all the areas contributing to drainage Zone A can be combined, and all the areas contributing to drainage Zone B can be combined, etc.

Drainage Table						
Drainage Zone	C		I (in. / hr)	A (sf)		Q (gpm)
Zone A	Roof	1.00	1.5	Roof	500	7.79
Zone A	Lawn	0.35	1.5	Lawn	900	4.91
TOTAL RUNOFF FOR ZONE A						12.7

What if the water passes over multiple surface materials on the way to the low point? For example, what if water runs off of the roof and then passes over the lawn before reaching the low spot? The runoff from the roof would need to be multiplied by the "C" value for the grass to calculate the portion of the roof runoff that will reach the low spot. The runoff from the grass area will remain the same. The revised roof runoff will be: (1.00 x 1.5 x 500) / 96.23 = 7.79 gallons per minute x 0.35 (runoff coefficient for lawn) = 2.73 gallons per minute. The total runoff equals 2.73 + 4.91 = 7.64 gallons per minute.

Weighted Average

Another way to calculate the drainage is find a weighted "C" value for the whole area contributing to the low spot. To calculate the weighted average, you take the multiply the area of each part for the zone by its corresponding "C" value. You then add these factors together and divide that by the total area of the contributing parts. Using the value above, the roof area is 500 square feet with a "C" value of 1.00. The lawn area is 900 square feet with a "C" value of 0.35. The weighted average for this is ((500 x 1.00) + (900 x 0.35)) / (900 + 500) = 0.58. So the runoff table for this area is:

Drainage Table						
Drainage Zone	C		I (in. / hr)	A (sf)		Q (gpm)
Zone A	Roof + lawn	0.58	1.5	Roof + lawn	1400	12.7

Now You Try: Calculate the runoff, Q, for each area in each drainage zone. Once you have calculated each runoff, combine the runoff for each drainage Zone.

An electronic version of a drainage calculator can be found at: http://www.ndspro.com/drainage-calculator.

Step 2. Calculate the Volume (V) of Water to be Stored

Don't worry, the hard part is done. The next step in is to determine the volume of water to be stored. Each municipality has their specific rules when it comes to determining how much water can be drained off of your property. A method that is commonly used is called the First Flush rule. The First Flush rule states that the first 15 minutes (or other duration determined by your municipality) of water from a storm must be stored on your property. Any water after that first 15 minutes can be discharged off your property. The reasoning behind the First Flush rule is that all of the pollutants, fertilizers, oils, and other chemicals that are on the surface will be washed off in the first 15 minutes of the storm. The goal is to prevent this polluted water from entering the public storm system. The public storm systems often drain directly to rivers, lakes, bays, and, oceans. Capturing and storing this polluted water on individual properties prevents our waterways from becoming polluted.

Storing the first 15 minutes of runoff from the 100-year storm event is usually sufficient storage capacity for most storms. If you want additional storage capacity, the runoff time can be increased to any desired length of time. To calculate the volume of water that needs to be stored, multiply the amount of runoff from each drainage zone by 15. The runoff for each zone was in gallons per minute. Multiplying by 15 minutes leaves you with the amount of gallons to be stored. Using the table below will help calculate the volume of water to be stored.

Drainage Zone	Q (gpm)	First Flush Time (minutes)	Volume (gallons)
Zone A	12.7	15	190.5

Now You Try: Calculate the volume of water to be stored in each zone by multiplying the runoff, Q, from each drainage zone by 15 minutes (or the required time length).

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Step 3. Determine How to Store Runoff

Now that you know the volume of water to be stored, we need to determine how to efficiently store this water. There are two ways that this water can be stored: 1) above ground in retention and detention ponds and 2) below ground in dry wells, french drains, etc. Below is a list of advantages and disadvantage of each method.

Storage Type	Advantage	Disadvantage
Above Ground	• No extra material needed • Cheaper to install • Easy to expand	• Large footprint • Safety fence required • Routine maintenance
Subsurface	• Invisible • Can be installed where it's needed • Easily connect to drain pipe	• Cost • Difficult to expand • Difficult to repair / maintain

How to Store Storm Water using NDS products

NDS is the leader in stormwater management and offers a variety of products that can help you efficiently store your storm water. The NDS Flo-Well and EZ-Drain are two products that can be easily installed by the average homeowner.

Step 3. (continued)

Flo-Well

NDS Flo-Well takes the place of a traditional gravel dry-well. A dry well is essentially a hole that is dug into the ground that is then backfilled with gravel. The problem with a traditional gravel dry-well is that after backfilling with gravel, the only space available to store water is in the space between the gravel. The space between backfill material is commonly called “void space”. The available void space for gravel is usually 30 to 40%. So for any given dry-well, only 30 to 40% of the original hole size can be used to store water.

The Flo-Well is a 2’ round barrel that is easily assembled and placed into a hole. A lid is then placed on the Flo-Well to prevent dirt from getting inside. The side panels have knockouts that easily remove to allow for a wide variety of pipes to be connected. Flo-Well provides 100% void space. Each Flo-Well can hold up to 50 gallons. In the case of our sample problem, 190.5 gallons of water need to be stored. 190.5 / 50 = 4 Flo-Wells would be required to store this volume of water. The Flo-Well can also be backfilled with gravel. If 1’ of gravel is placed below the Flo-Well, and 1’ of gravel is placed around the perimeter of the Flo-Well, then 145 gallons of water can be stored with each Flo-Well. 190.5 / 145 = 2 Flo-Wells required.

For additional information on Flo-Wells, go to:
http://www.ndspro.com/drainage-systems/dry-wells/flo-well-dry-well

Drainage Zone	Required Storage	Flo-Wells Required
Zone A	190.5	190.5 / 50 = 4 -OR - 190.5 / 145 = 2

Now You Try: Using the required storage for each drainage zone, calculate the required number of Flo-Wells using either 50 gallons per Flo-Well (no gravel backfill) or 145 gallons per Flo-Well (with gravel backfill). NDS has provided a Flo-Well calculator that can be used to determine the number of Flo-Wells that would be needed for your job.

The Flo-Well calculator can be found here: http://www.ndspro.com/flo-well-calculator

Step 3. (continued)

EZ Drain: EZ-Drain is an all-in-one gravel-free alternative to a traditional French drain. A French drain is a perforated pipe surrounded by gravel and a geotextile fabric that allows water to slowly percolate into the ground over the whole length of the trench. The two major disadvantages of a traditional French drains are all of the labor-intensive steps required to install the drain and the reduced flow rate in the stone versus the poly-rock aggregate in EZ-Drain. EZ-Drain can be installed in 50% the time and has 30% faster flow rates than traditional French drains. The table below shows a comparison between a traditional gravel French drain and EZ-Drain.

EZ-Drain	Traditional Gravel French Drain
At least 50% faster installation	Traditional Installation
Dig trench	Dig Trench
Place EZ-Drain in trench	Line trench with filter fabric
Backfill	Shovel gravel into trench
Installation effort	Place pipe in trench
No gravel	Fill trench with gravel
Light Weight - 1 person can carry 50' of EZ-Drain	Cover gravel with fabric
All-in-one package	Backfill
45% void space in Polyrock	Lifting, shoveling, and wheel barrowing of heavy gravel
Increased Storage capacity	Separate purchases for fabric, pipe, gravel. Availability, cost, and delivery of gravel
30% faster flow rates through Polyrock	30-40% void space in gravel
Water quickly enters the pipe and is carried away	Varies with rock and amount of sand mixed in
from home	Flow rates through rock varies with rock and amount of sand mixed in

EZ-Drain is lightweight and easy to install, and can be used anywhere that a traditional French drain is installed. It is available in 7" and 8" total diameter. The 7" diameter is available primarily in California, and the 8" everywhere else. After digging the trench, 10' EZ-Drain sections are connected to each other using a coupler and then the entire unit is laid in the trench. Once EZ-Drain is in the trench, all you need to do is backfill. Everywhere that drain pipe is used, EZ-Drain can be substituted. The internal pipe of EZ-Drain is used to convey water and the surrounding polyrock can be used as storage. The table below gives the storage and flow capacities of EZ-Drain.

For more information on EZ-Drain, go to: http://www.ndspro.com/drainage-systems/french-drains/ez-drain-french-drain

Product	Storage Volume per 10' piece (gallons)	Flow Capacity (gpm)
7" Diameter	11.4	80.8
8" Diameter	15.8	112.7

To store 190.5 gallons, (190.5 / 11.4) = 17 – 7" bundles or 12 – 8" bundles are required.

Drainage Zone	Required Storage	EZ-Drain Required
Zone A	190.5	190.5 / 11.4 = 17 - Or - 190.5 / 15.8 = 12

Now You Try: Using the required storage for each drainage zone, calculate the required number of EZ-Drain bundles using either 11.4 gallons per 10' (7" diameter) bundle or 15.8 gallons per 10' (8" diameter) bundle. NDS has provided an online calculator that can be used to determine the length of trench and quantity of EZ-Drain bundles that are required for your job.

This calculator can be found at: http://www.ndspro.com/ezdrain-calculator

Step 3. (continued)

Combination of Flo-Wells and EZ-Drain

Since EZ-Drain can be used in place of drain pipe, the storage capabilities can be EZ-Drain can be used. If 40' of traditional drain pipe are to be used to drain water to a Flo-Well, 45.6 (or 63.2) gallons or water can be stored over the length of that pipe if EZ-Drain is used. That eliminates the need for 1 Flo-Well. The combination of EZ-Drain and Flo-Wells allows for an infinite number of drainage configurations. A Flo-Well can be placed at a low spot in a yard with EZ-Drain branching out to either collect additional surface water, or discharge water over a larger area.

Drainage Zone	Required Volume	# of EZ-Drain	Volume in EZ-Drain	# of Flo-Wells	Volume in Flo-Wells	Volume Provided
Zone A	*190.5*	*4*	*45.6*	*3*	*150*	*195.6*

Now You Try: Using the required storage for each drainage zone, calculate the required number of EZ-Drain bundles and Flo-Wells if they are used together. Use a table like the one above to help with the calculations.

Conclusion: Please check with your public municipality before beginning any grading or drainage work on your property. By following the steps outlined above, you can calculate the drainage requirements for your property. Be sure to keep track of all your work on a separate sheet of paper. Working slowly and carefully through each step will help you come up with the correct solution to your drainage calculations.

Additional Question: If you have additional questions, feel free to contact me at drdrainage@ndspro.com.

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Catch Basins

The NDS 12 in. x 12 in. Catch Basin 2-Opening Kit features UV-resistant 1-piece injection-molded structural polypropylene construction for strength. Use in areas where water buildup occurs. Use to catch and divert water to water safe areas away from structures, erosion-prone landscapes and poor drainage areas.

shop.ndspro.com/c/catch-basins_square-catch-basins

Channel Drains

The pre-assembled modular Pro Series channel drains are efficient, easy to use and will decrease installation time.

This modular Pro Channel features a unique interlocking design which allows each channel to securely lock to the next for a secure, tight fit. Includes 1 meter (39-3/4") of channel drain and grate, 1 end outlet and 1 end cap.

shop.ndspro.com/c/trench-channel-drains_3-pro-series-drain

Flo-Well

Flo-Well offers on-site solutions to retain storm water and discharge it into the subsoil. Complies with new storm water regulations

shop.ndspro.com/c/flo-well-dry-well

EZ-Drain

EZ-Drain drainage systems are designed for use in residential and light commercial non-traffic applications. EZ-Drain drainage systems are designed to withstand single pass construction wheel loading and occasional light vehicular load of up to 16,000 lbs per axle provided the product is installed in a trench with 12" of compacted fill placed over the bundles. EZ-Drain drainage systems are not designed to be placed under live-load traffic conditions such as paved or non-paved roadways, driveways, or parking areas.

ndspro.com/drainage-systems/french-drains/ezflow-french-drain

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