AUTODESK
Official Press

Eric Chappell

Autodesk® Drainage Design for InfraWorks® 360

ESSENTIALS

Second Edition

SYBEX
A Wiley Brand

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To Earl Waddell

Acknowledgments

Even though I now work for Autodesk, it is amazing to me how far this software has advanced in a single year. So much has happened with Drainage Design for InfraWorks 360 that I had to create an additional chapter to cover it all. These are truly exciting times in the world of design software, and I'm so fortunate to have a role in it.

Thanks to Stephanie McComb for getting this book out of the gate for a second edition and for working with me on some very demanding schedules. Tom Richardson was the technical editor for this and all the other InfraWorks 360 books, and I can't think of anyone else I'd rather have when it comes to providing a thorough and insightful technical working over. And last but certainly not least, thanks to Kim Wimpsett and Kathy Grider-Carlyle for your tireless efforts correcting my writing and making it so much better.

I say it in every book, and it's true every time: my family takes the brunt of the condition that is book writing. I hope that all of the time and effort is worth it and that this book, like the others, will serve as an example of quality work to my children and a source of pride for my wife.

About the Author

Eric Chappell has been working, teaching, writing, and consulting in the world of civil engineering software for more than 20 years, and he is a recognized expert in the world of Autodesk® InfraWorks® 360 software. In September 2013, Eric joined the Autodesk family as a Premium Services Specialist and has since taken on the role of Community Evangelist for InfraWorks 360. In the 12 years prior to working for Autodesk, he wrote training materials and performed training for end users, trainers, and Autodesk employees around the globe. For several years, he has worked with Autodesk in authoring and developing two Autodesk certification exams. He also served as design systems manager for Timmons Group, a civil engineering and surveying firm based in Richmond, Virginia, where he managed software, standards, and training for more than 200 users. Eric is also a highly rated instructor at Autodesk University, where he has taught for the past 10 years.

Prior to writing and consulting, Eric spent nearly 10 years in the civil engineering and surveying fields while working for the H.F. Lenz Company in Johnstown, Pennsylvania. During his time at H.F. Lenz, he gained considerable practical experience as a survey crewman, designer, engineer, and CAD supervisor. Eric also holds a B.S. degree in civil engineering technology from the University of Pittsburgh at Johnstown and is certified in Pennsylvania as an EIT.

Eric is originally from southwestern Pennsylvania, but he has lived in the Richmond, Virginia, area for the past 14 years with his wife and four children. He enjoys being outdoors and spending time with his family. He can sometimes be seen playing drums for the band Sons of Zebedee, which performs at a variety of events in central Virginia.

If you would like to contact the author regarding comments or suggestions, please email `InfraWorksEssentials@gmail.com`. You are also welcome to visit Eric's blog at `http://erichappell.blogspot.com`.

Contents at a Glance

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Introduction

I can't imagine writing a book or learning a new program in a more exciting time. We in the civil engineering, planning, construction, geospatial, and other related fields are experiencing the "changing of the guard," a new era in design software technology. The Autodesk® AutoCAD® Civil 3D® software is still the powerful flagship that is a global monument to civil engineering design, but there is a new kid on the block—and he's quick, smart, and attractive, and he's a great communicator. His name is Autodesk® InfraWorks® 360.

InfraWorks 360 has already begun revolutionizing the way design is done, and one of its greatest attributes is that it is simply fun to use. But not only is it fun, it employs powerful engineering principles and methods to create designs that are much more than just pretty pictures. You could say that using InfraWorks 360 is like playing a video game and getting work done at the same time.

This is the second edition of this book, and this time around, I plan to stick to the formula that has been successful for four editions of AutoCAD Civil 3D Essentials and last year's family of InfraWorks 360 Essentials books. That formula is as follows:

- The book should be basic enough to enable anyone to learn Drainage Design for InfraWorks 360.
- It should be in-depth enough to enable a person to be productive using Drainage Design for InfraWorks 360 for basic tasks.
- It should foster understanding by associating the things you do in Drainage Design for InfraWorks 360 with familiar things you see every day.
- The examples and exercises should be based on the real world.
- The book should not simply demonstrate random software features, but it should also teach the process of project completion using Drainage Design for InfraWorks 360.

While writing each chapter of this book, I have tried to meet these criteria. I hope before opening this book, you have gone through *Autodesk® InfraWorks® 360®* and *Autodesk® InfraWorks® 360 LT Essentials* and have become familiar with the concept of InfraWorks 360, its user interface, and its environment. In addition, I hope you have completed the *Autodesk® Roadway Design for InfraWorks® 360 Essentials* and *Autodesk® Bridge Design for InfraWorks® 360 Essentials* books. Just as Drainage Design for InfraWorks 360 is built upon

InfraWorks 360, this book is built upon its counterparts. In addition, if you've experienced any of the aforementioned InfraWorks 360 books, then you're also familiar with the Bimsville Bypass project. In this book, you'll create, modify, and analyze watersheds, culverts, and drainage networks along the Bimsville Bypass and neighboring proposed industrial park.

The Full InfraWorks Essentials Library

This ebook is part of a complete library covering InfraWorks 360 and its vertical applications. All are available at Sybex.com and through a variety of online resellers.

Autodesk® InfraWorks® 360 and InfraWorks® 360 LT Essentials

Autodesk® Roadway Design for InfraWorks® 360 Essentials

Autodesk® Bridge Design for InfraWorks® 360 Essentials

Autodesk® Drainage Design for InfraWorks® 360 Essentials

Who Should Read This Book

This book should be read by anyone who already understands the core InfraWorks 360 features as well as the Autodesk® Roadway Design for InfraWorks® 360 features and is ready to move on to drainage design. It is designed to be used in a formal classroom environment, in your home office learning on your own, and everywhere in between. It is appropriate for ages ranging from high school to retirement, and although it is intended for those who have no experience or skill with Drainage Design for InfraWorks 360, it can also serve as a great resource for refreshing one's knowledge base or for filling in any gaps.

Here are some specific examples of individuals who would benefit from reading this book:

- Anyone involved in the planning or preliminary design stages of infrastructure or land development projects
- High-school students following a design-related educational track

- College students learning to be designers, engineers, or GIS professionals
- Employees who have recently joined a company that utilizes InfraWorks 360
- Employees who work for companies that have recently implemented InfraWorks 360
- Experienced InfraWorks 360 users who are self-taught and who want to fill in gaps in their knowledge base
- Civil 3D users

What You Will Learn

The goal of this book is to make you productive with Drainage Design for InfraWorks 360 in a relatively short time. It begins by giving you a detailed tour of the user interface and the environment you will be working in. It then covers nearly all of the Drainage Design for InfraWorks 360 features using relatively simple but realistic examples. It takes you through the progression of a project (the Bimsville Bypass) so that you can learn the logic of how Drainage Design for InfraWorks 360 is applied to make projects more successful.

After completing this book, you will be able to use Drainage Design for InfraWorks 360 to create, modify, and analyze preliminary drainage designs in your InfraWorks models. You will be able to work on a team that also uses Drainage Design for InfraWorks 360, and you will be able to create and share drainage design models with them.

What You Need

The following sections highlight the key things you will need to successfully complete the entire book.

Software

To work through the exercises in this book, you will need to have the latest version of InfraWorks 360 installed on your computer, with Drainage Design for InfraWorks 360 enabled. You should refer to the Autodesk website (`www.autodesk.com`) and make sure your computer's specifications are equal or better than the recommended system requirements for the current release of these products. InfraWorks 360 software has historically been updated several times throughout a given year, so be sure to check the Autodesk website for the latest version as well as the website for this book (`www.sybex.com/go/drainagedesignessentials2e`) for any additions or updates resulting from a software update.

An InfraWorks 360 Account

For Drainage Design for InfraWorks 360 to be enabled, you must have InfraWorks 360 installed. Autodesk InfraWorks LT does not have the ability to accept Drainage Design for InfraWorks as an add-on program. You must also be entitled to Drainage Design for InfraWorks 360 either as a trial version or through your Autodesk account. If you work for a company or organization, check with a software manager within your organization about getting set up with the proper software and entitlements. Or, if you do not have such a person in your organization, contact your Autodesk reseller. You can also visit `www.autodesk.com/infraworks` for more information.

Access to Cloud Credits

Several tasks in the exercises will require cloud credits for you to complete. Check with your software administrator or with an Autodesk representative to ensure that you have access to cloud credits. If you do not, you can skip that portion of an exercise and go on to the next exercise. The need for cloud credits impacts only a small portion of the book.

Exercise Files

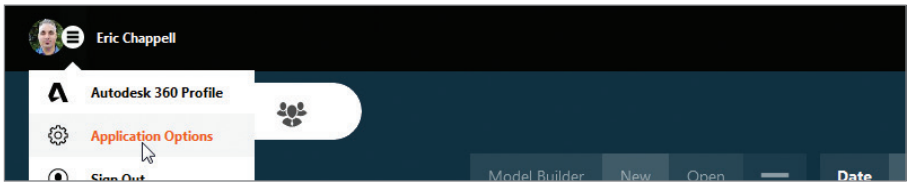
To complete the exercises, you will need to download the necessary files from `www.sybex.com/go/drainagedesignessentials2e` Here you will find a list of

ZIP files, one for each chapter, which you should unzip to the local C: drive of your computer. This will create a folder named `InfraWorks Drainage Essentials` with the chapter folder inside it. As you unzip additional chapter files, simply merge the new `InfraWorks Drainage Essentials` folder into the old one.

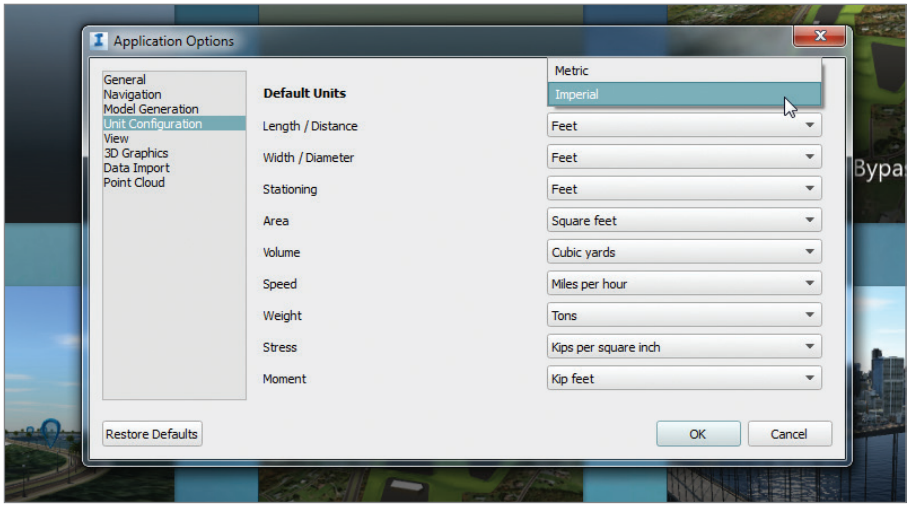
Configure Your Units

When you begin using InfraWorks, you will need to configure it for either imperial or metric units. Here are the steps:

1. Launch InfraWorks.
2. On InfraWorks Home, click the sign-in icon, and then click Application Options.



3. In the Application Options dialog, click Unit Configuration.
4. For Default Units, select either Imperial or Metric, depending on the units with which you prefer to work.



Know Which Units to Use

As you work through the book, you will see dimensions provided twice: once in Imperial units and then again as metric units in parentheses. The following is an example step from an exercise:

> **9.** Click the height gizmo and enter a value of **150** (**45**) in the tooltip. Press Enter. Press Esc to clear the selection of the building.

In this example, you would enter **150** if you are working in Imperial units and **45** if you are working in metric units. Note that 45 meters is not the exact metric equivalent of 150 feet, but a practical approximation.

Check for Updates

Be sure to check the book's website, `www.sybex.com/go/drainagedesignessentials2e`, for any updates to this book should the need arise. You can also contact me directly by email at `InfraWorksEssentials@gmail.com`.

The Essentials Series

The Essentials series from Sybex provides outstanding instruction for readers who are just beginning to develop their professional skills. Every Essentials book includes skill-based instruction with chapters organized around projects rather than abstract concepts or subjects, plus digital files (via download) so you can work through the project tutorials.

What Is Covered in This Book

Autodesk Drainage Design for InfraWorks 360 Essentials is organized to provide you with the knowledge needed to master the basics of the Drainage Design module.

Chapter 1: Getting Started Familiarizes you with the concept of Drainage Design for InfraWorks 360 and gives you a detailed account of all the tools available through its user interface.

Chapter 2: Working with Watersheds and Culverts Demonstrates how to create, modify, and analyze watersheds and culverts utilizing a number of tools.

Chapter 3: Working with Drainage Networks Demonstrates how to create, modify, analyze, and quantify drainage networks utilizing a number of tools.

How to Contact the Author

I welcome feedback from you about this book or about books you'd like to see from me in the future. You can reach me by writing to `InfraWorksEssentials@gmail.com`. For more information about my work, please visit my blog at `http://erichappell.blogspot.com`.

Sybex strives to keep you supplied with the latest tools and information you need for your work. Please check its website at `www.sybex.com/go/drainagedesignessentials2e`, where we'll post additional content and updates that supplement this book if the need arises.

CHAPTER 1

Getting Started

Autodesk® Drainage Design for InfraWorks® 360 software is a vertical application that runs in the Autodesk® InfraWorks® 360 software. It provides additional functionality for performing hydrologic and hydraulic design and analysis for land-development and infrastructure projects. It is an excellent tool for performing stormwater design and analysis in the early stages of a project.

In this chapter, you'll learn to

- **Identify and understand the capabilities of Drainage Design for InfraWorks 360**
- **Understand and navigate the additions to the InfraWorks 360 user interface**

Understanding the Capabilities of Drainage Design for InfraWorks 360

The Drainage Design for InfraWorks 360 vertical application extends the capabilities of InfraWorks 360 software by offering advanced design tools for hydrologic and hydraulic analysis and design. To gain an understanding of how these advanced capabilities are integrated into the software, you'll look at several areas, including watershed analysis, culvert design, pavement drainage design, and quantities.

Watershed Analysis

Before designing the infrastructure that will serve the drainage needs of your site, you must first calculate the flows that the infrastructure will be required to handle. You can determine flow through hydrologic analysis, and the watershed tools in Drainage Design for InfraWorks 360 are built for this purpose. You will study the capabilities of these tools in two major areas: delineating watersheds and calculating flows.

Delineating Watersheds

When you're analyzing the hydrology of a project, one of the first tasks that must be performed is delineating *watersheds* (areas that drain to specific points of interest). In Figure 1.1, you see a watershed shaded in blue, which represents the area that drains to a point beneath a bridge. In other words, when there is a rain storm, every drop of rain that hits the ground within that blue area (and is not absorbed into the ground) will flow beneath the bridge. In many cases, designers are most interested in analyzing the amount of stormwater flow that enters a structure, such as a culvert or inlet. Many methods are available for determining that flow, but most, if not all of them, require that the watershed for that structure has been determined.

FIGURE 1.1 **The blue shaded area is a watershed contributing flow under the bridge shown near the center of the image.**

The process for delineating a watershed requires an analysis of the terrain to determine how the varying slopes of your site direct runoff toward and away from a given point of interest. This requires some serious computations, and that's where the cloud computing power of InfraWorks 360 plays a key role. Drainage Design for InfraWorks 360 has the capability to harness the power of the cloud to compute and delineate drainage areas for individual points or entire stretches of road (see Figure 1.2).

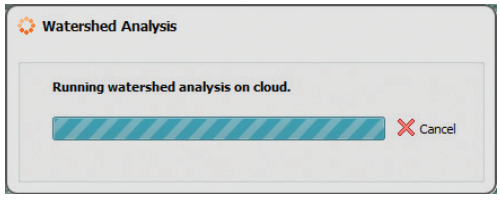


FIGURE 1.2 The InfraWorks 360 software is leveraging the cloud to perform a watershed analysis.

Calculating Flow

Once a watershed is delineated, the next step in the process is to calculate the flow to the point of interest. Across the world, many different methods are used to calculate this flow, but there are common themes among all of them. See the sidebar "One Method: The Rational Method" to get an idea of how one of these methods works. InfraWorks 360 enables you to choose from a number of methods to determine how to calculate the predicted flow for a given point of interest. Where applicable, you can also supply important information that is used in the calculations. This is all done through the Watershed asset card (see Figure 1.3).

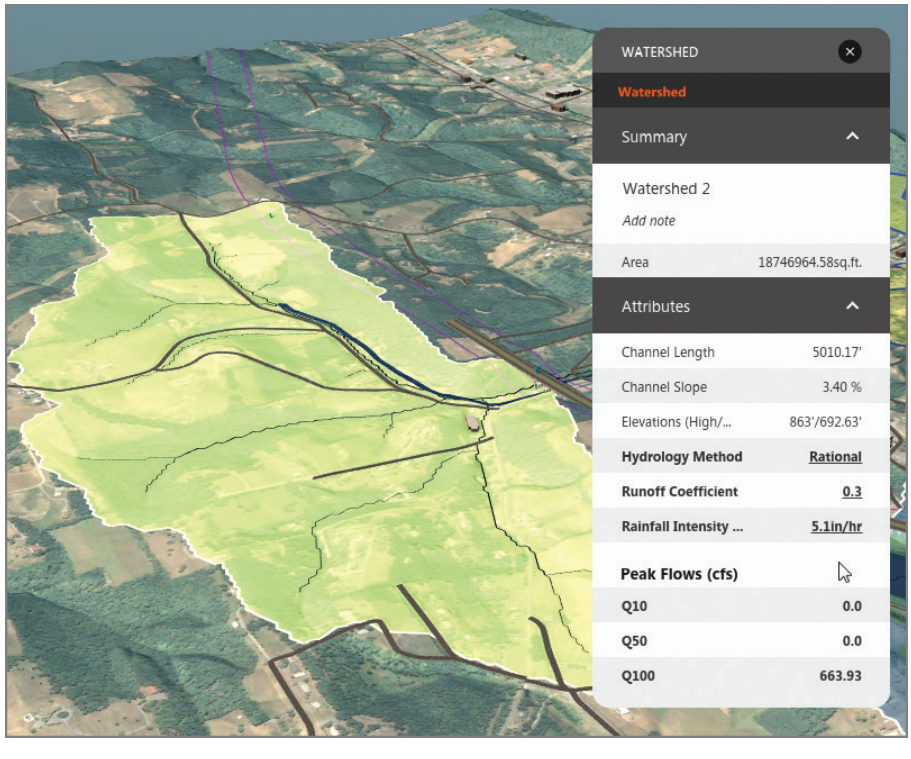


FIGURE 1.3 The Watershed asset card is being used to calculate the flow for the watershed shown to the left of it.

One Method: The Rational Method

If you are new to the concepts of hydrologic analysis, the Rational Method is a good place to start. The Rational Method uses a simple equation to calculate the predicted flow to a given point based on the terrain, land cover, and historical rainfall data. The formula for the Rational Method is $Q = CIA$.

- Q is the predicted flow measured in units of volume per units of time. For example, cubic feet per second (CFS) is often used for Imperial units, and cubic meters per second (CMS) is used for metric units.
- C is the runoff factor, which ranges from 0 to 1. Nearly impervious surfaces such as asphalt or concrete are represented with high C values in the 0.7 to 0.9 range. Densely forested areas are much lower, in the 0.1 to 0.3 range. Everything else falls somewhere in between. The C factor represents the amount of rainfall that is *not* absorbed into the ground and, therefore, allowed to flow over it. For example, an area that is paved may have a C factor of 0.85, which is a way of saying that 15 percent of the rainfall will be absorbed into the ground and the remaining 85 percent will stay on top of the ground and become runoff.
- I in the rational method equation stands for intensity and indicates the expected severity of the rainfall. Time of concentration also factors into determining the I value for the Rational Method. The time of concentration is the amount of time that it takes for every bit of a watershed to contribute flow to the point of interest (see the sidebar "Concentrate to Understand Time of Concentration").
- A is simply the area of the watershed contributing to the point of interest.

So, if you simply think about the equation $Q = CIA$, you realize that watersheds that are more impervious (higher C), see more intense rainfall (higher I), and cover larger areas (higher A) will generate higher flows (Q). Makes sense!

Concentrate to Understand Time of Concentration

What is time of concentration, and why should you care about it? When analyzing watersheds, you often will be most concerned with peak flow—the highest flow that will occur during a storm event. If you were to make a graph of this flow (called a *hydrograph*), it typically has a bell shape, with the flow starting small, increasing to a point, and diminishing to zero. At first, you might think

(Continues)

Concentrate to Understand Time of Concentration *(Continued)*

that happens because the rain starts out light and then gets heavier and finally subsides, but that's not the reason. Even if you could turn the rain on with a switch and have it start and end with the same intensity, you would still see this bell curve representing the flow. What gives?

The rain that falls must travel a certain distance to reach the point of interest: the outlet of the watershed. A few seconds into the rain event, only the raindrops that have fallen closest to the outlet have had enough time to get there, so the flow is small. After a minute, raindrops that fell, say, 100 feet away are now reaching the outlet *plus* all the ones that are continuing to fall between 0 and 100 feet away, so the flow increases. After five minutes, raindrops are arriving that fell, say, 500 feet away *plus* all of the ones that are continuing to fall between 0 and 500 feet away, so the flow increases. Eventually, the last spot in the watershed, a corner that is maybe 752 feet away, has finally provided a raindrop to the outlet, and perhaps it took 7.36 minutes for it to get there. Now, every square inch of the watershed is contributing flow to the outlet, and the flow has reached its peak. The time of concentration is 7.36 minutes.

Make sense? If so, take a deep breath and get ready for a little more. That last raindrop is not necessarily the furthest away—technically, it is simply the one that took the longest to get there. It is possible that a raindrop that is far away traveled down a path quickly because there was little resistance (perhaps a curb or steep concrete channel), whereas a closer one had to travel across a forest floor that was relatively flat. So, figuring out the time of concentration involves more than just measuring how far it is from the outlet to the farthest spot in the watershed. There's more, but I'll leave it at that.

Culvert Design

As you probably already know, road design is a big part of the InfraWorks 360 package—so much so that the Autodesk® Roadway Design for InfraWorks® 360 vertical application is dedicated to it. Whenever roads are built across the landscape, there are always drainage concerns to consider, and one of the primary ones is allowing drainage ditches, streams, and rivers to pass beneath the road. Bridges are required for larger waterways (by the way, there is a vertical application for bridges too: Autodesk® Bridge Design for InfraWorks® 360), but for small-flow applications, culverts are the solution. Drainage Design for InfraWorks 360 contains a powerful set of culvert design tools that enable you to quickly create, design, and adjust culverts (see Figure 1.4).

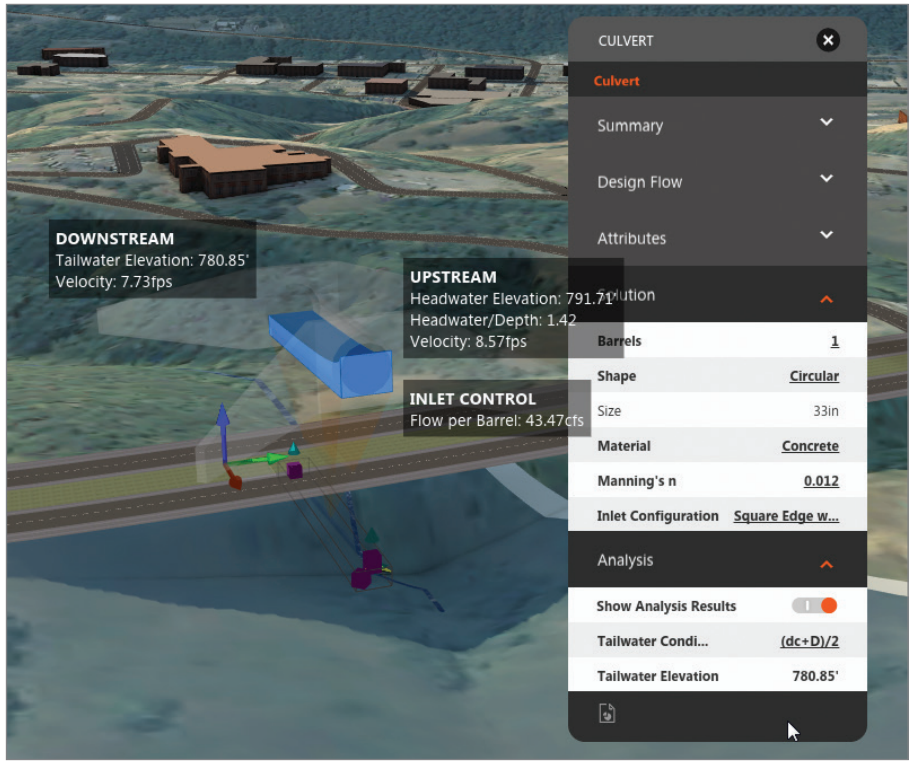


FIGURE 1.4 The configuration of a culvert where a design road crosses a stream

Automated Culvert Design

When you use the Create Watersheds command to delineate watersheds in your model, another product of that command is a series of stream networks. If any stream in a given stream network crosses beneath a road, with a single command you can have InfraWorks 360 automatically create culverts at those locations. Not only will the culverts be created at the proper location, they will be properly sized based on the flows calculated for the associated watersheds. Better yet, when you make changes to the road, such as adding lanes or adjusting the alignment, the culverts will automatically update to accommodate. Culverts are the products of the interactions between the roads, watersheds, and stream crossings, and they will respond to changes in any of those components.

If you do not want to perform a watershed analysis, you can still create culverts automatically at places where rivers cross beneath a road. In this case, the culverts will not "know" their design flows and, therefore, will not be sized, but they will respond to changes in the design of the road such as changing the

number of lanes, moving the road, or changing where the road ties to the existing terrain. Figure 1.5 shows a culvert that has been placed in this manner.

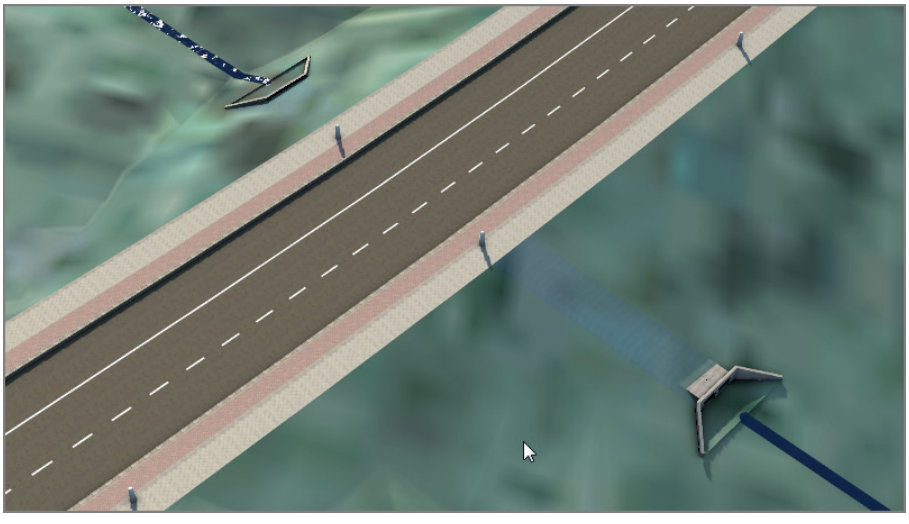


FIGURE 1.5 A culvert that has been placed where a river crosses beneath a road

Manual Culvert Placement

You can also manually place a culvert in the model by launching the Culverts command and simply picking two points to indicate the start and end. The inverts of the culvert will automatically match the terrain by default, but you can change those elevations using familiar techniques such as dragging gizmos or using the Properties panel. This approach, although not tied to any other design components, gives you complete control over the placement of a culvert. The culvert in Figure 1.6 was placed manually with no stream or water area present.

FIGURE 1.6 A manually placed culvert

Culvert Content

As you design culverts using Drainage Design for InfraWorks 360, you'll be impressed by the number of choices you have for culvert shapes, number of barrels, and end configurations. With all these choices, you can perform detailed designs that conform to your project conditions as well as configurations that match local construction practices and available materials. Figure 1.7 shows a user choosing the wingwall configuration for a culvert.

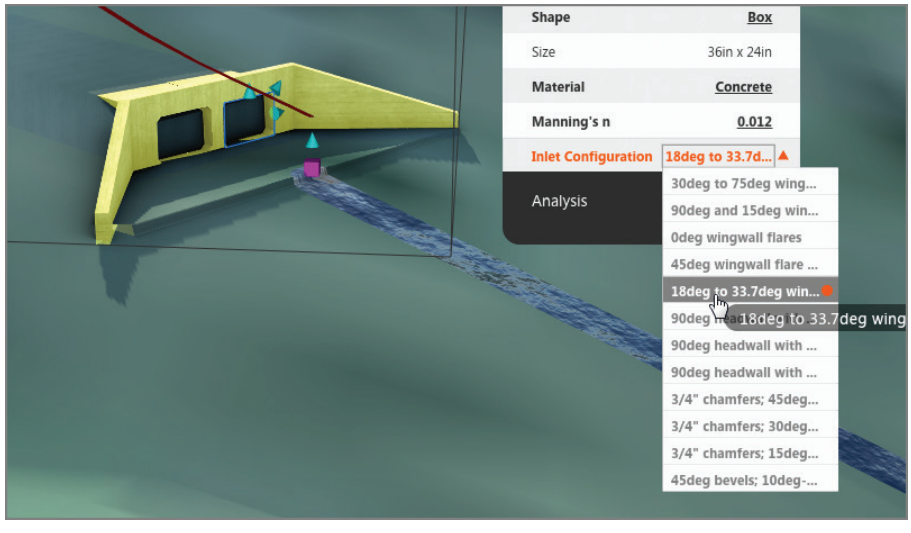


FIGURE 1.7 Choosing a wingwall configuration

Culvert Analysis

Once you have placed and sized a culvert, InfraWorks 360 will perform a basic analysis and provide results to you in two ways. The first is a visual analysis showing you a 3D graphic of the hydraulic grade line along with key values relating to elevations, depths, flows, velocities, and so on (see Figure 1.8). The second way that InfraWorks 360 provides results is by giving you the ability to export the results to a file that can be imported into another product for further analysis.

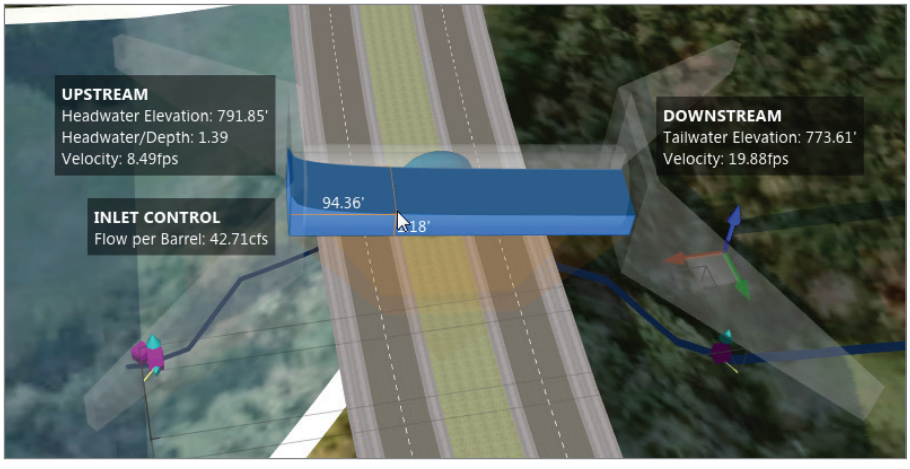


FIGURE 1.8 Culvert analysis

Drainage Networks

Another important drainage design consideration is the collection and conveyance of runoff on the road surface itself. Drainage Design for InfraWorks 360 provides the ability to create drainage networks for this purpose, either automatically or manually.

Automatic Creation

In much the same way that InfraWorks 360 will create, position, and design culverts for you, it will also place inlets, manholes, and pipes along a design road automatically based on design rules and common engineering assumptions. Figure 1.9 uses a transparent road style to show a portion of a drainage network that was automatically created in this manner.

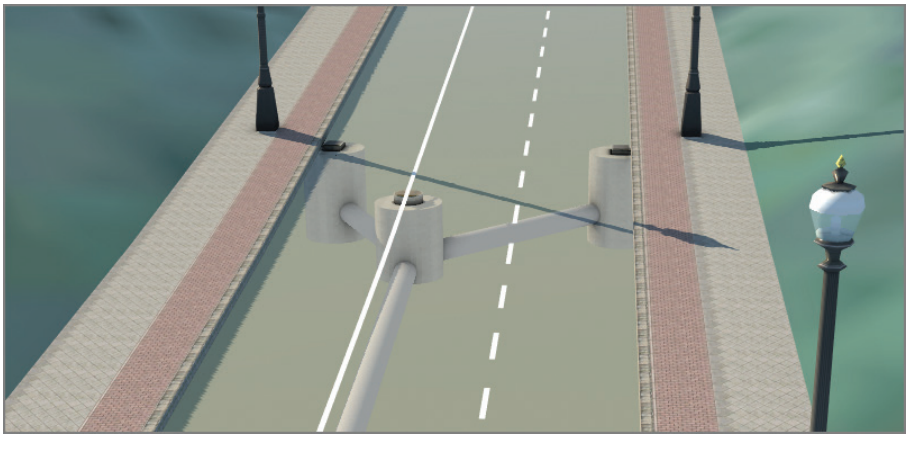


FIGURE 1.9 A drainage network created automatically for a road

Automatic Sizing

Once it's in place, you can have the entire network sized with one command by simply right-clicking the design road that it is associated with and selecting Size Pavement Drainage (see Figure 1.10).

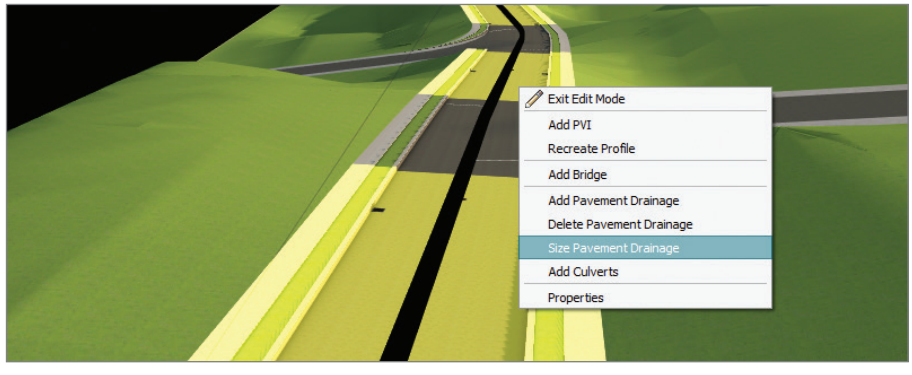


FIGURE 1.10 Sizing pavement drainage

Analyzing Pipes for Performance

You can analyze individual pipes using the Inspect Performance command to view a graphical representation of the hydraulic grade line (HGL), energy grade line (EGL), and other information (see Figure 1.11).

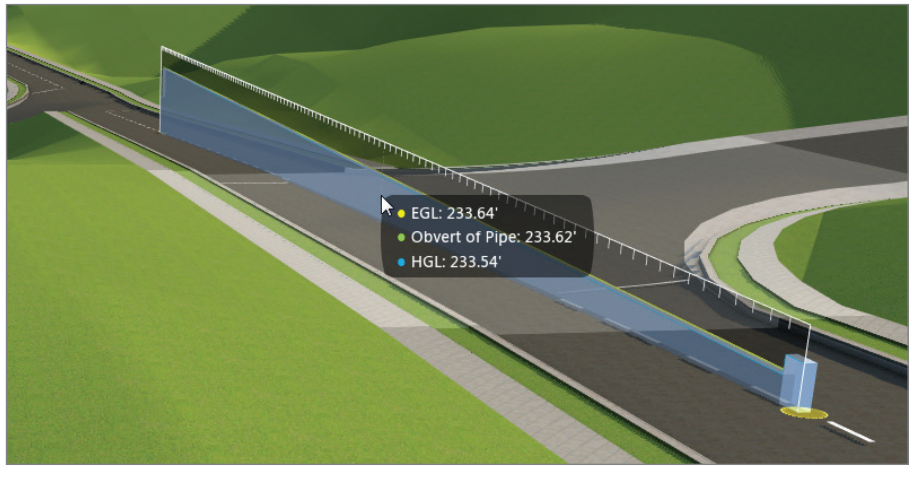


FIGURE 1.11 Analyzing the performance of a pipe using the Inspect Performance command

Analyzing Inlets for Performance

You can analyze inlets and observe graphical representations of the tributary area and spread, interactive graphics that report the spread and depth values, and numerical values that report the intercepted flow, efficiency, and other important information (see Figure 1.12).

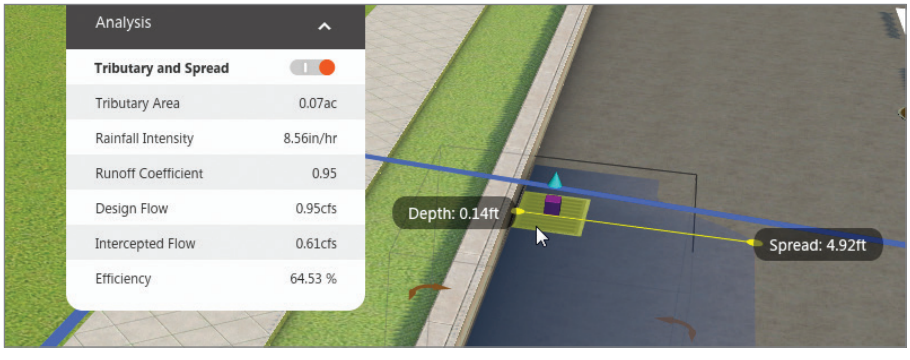


FIGURE 1.12 Analyzing inlet performance

Detailed Design

Of course, individual components can be modified so that the design can be adjusted to meet the needs of the project. So that you can assign the appropriate design in each case, an extensive library of inlet and manhole types is available to choose from (see Figure 1.13). Drainage network components can also be placed manually to add more detail to an automatically created network or to simply create a network from scratch, giving you full control of the placement of the components.

Quantities

Another useful task that Drainage Design for InfraWorks 360 will perform is tabulating drainage quantities for a given road. This comes in handy when performing cost analysis for a given road by providing quantities for culverts as well as drainage network components (see Figure 1.14).

FIGURE 1.13 Choosing an inlet type from the available library

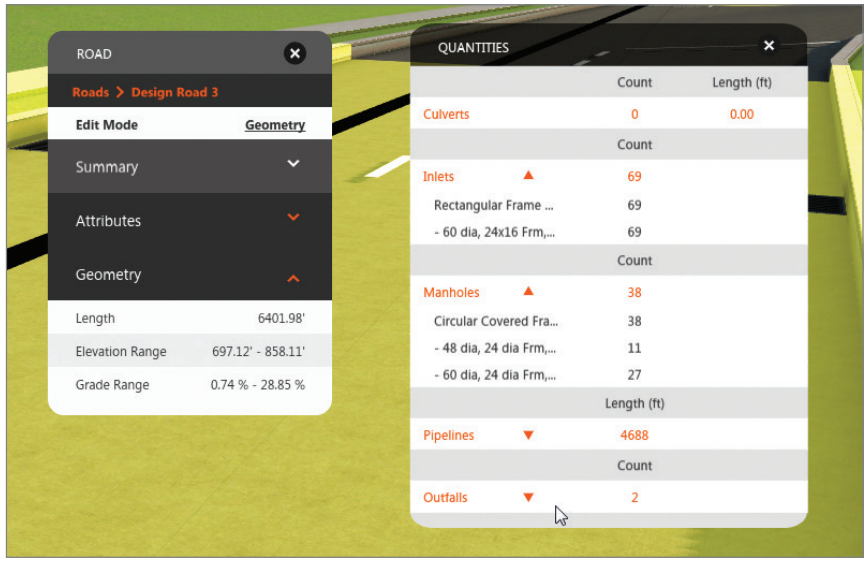


FIGURE 1.14 Drainage quantities for a road

The Drainage Design User Interface

As you might guess, Drainage Design for InfraWorks 360 adds some new user interface components to InfraWorks 360. These include additions to the Intelligent Tools, asset cards, and right-click menus.

Drainage Design Intelligent Tools

With Drainage Design for InfraWorks 360 enabled, you will see a bluish-green pipe icon on the main toolbar that I'll call the Drainage Design icon. This icon expands to reveal the Drainage Design toolbar, which contains an Analyze icon, a Design icon, and a Review icon (see Figure 1.15). Each one of these icons opens a toolbar along the left side of the screen. I'll refer to these toolbars as the Analyze, Design, and Review toolbars. As with other InfraWorks 360 modules, these toolbars contain a mixture of basic InfraWorks 360 commands along with commands that are exclusive to Drainage Design for InfraWorks 360.

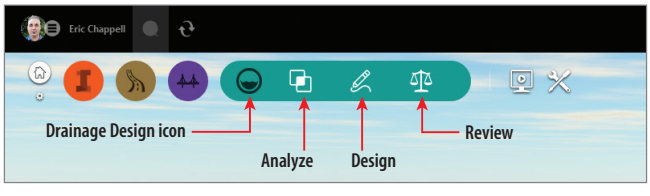


FIGURE 1.15 The Drainage Design toolbar

Analyze Toolbar

The Analyze toolbar contains five tools; two are part of the core InfraWorks 360 tools, and three are from the Drainage Design tools.

Terrain Themes Terrain Themes is a core InfraWorks 360 command. It opens the Terrain Themes panel where you can configure a theme to color-code a terrain based on elevation, slope, or *aspect* (direction in which hillsides face).

Create Watersheds This command uses the InfraWorks 360 cloud capabilities to analyze the terrain of the model and identify watersheds and streams. It creates new watershed and stream objects in the model that you can use for further design and analysis.

Surface Layers Surface Layers is a core InfraWorks 360 command. Surface layers are the parts of the model that rest on the ground. This icon opens a panel that lets you manage the visibility of these objects.

Quantities This prompts you to select a design road. When you do, it opens the Quantities asset card, which reports culvert and drainage network quantities to you.

Inspect Performance This prompts you to select two pipe connectors. After you do, it will provide an analysis of the pipe between them.

The Design Toolbar

The Design toolbar contains eight tools; five are part of the core InfraWorks 360 set of tools, and three are from the Drainage Design tools.

Coverages The Coverages command is a core InfraWorks 360 command. You can think of *coverage* as an area of land that is covered with something. That something can be grass, pavement, concrete, sand, or just about anything. Coverages can also be used to shape the land that they cover.

Culverts This will launch the manual Culvert tool and prompt you to pick two points defining either end of a culvert.

Points Of Interest Points Of Interest is a core InfraWorks 360 command. You use this command to create points of interest to call out important locations in your model. Any 3D model can be used as a marker for a point of interest.

Rivers Rivers is a core InfraWorks 360 command. Use this command to draw rivers, creeks, canals, and other linear waterways by clicking points along a path.

Water Areas Water Areas is a core InfraWorks 360 command. You use this command to draw lakes, ponds, and other water features defined by closed shapes.

Drainage Networks You use this command to create inlets, manholes, pipelines, and outfalls that represent drainage networks in your model.

Create Watersheds This command will use the InfraWorks 360 cloud capabilities to analyze the terrain of the model and identify watersheds and streams. It will create new watershed and stream objects in the model that you can use for further design and analysis.

Style Palette Style Palette is a core InfraWorks 360 command. The appearance of objects in InfraWorks 360 software is controlled by styles. Every InfraWorks 360 model has a library of styles that you can pull from and apply to

objects to quickly change their appearance. The Style Palette command presents that library to you in an organized fashion. You can also create your own styles and add them to the Style Palette.

The Review Toolbar

The Review toolbar contains six tools; five are part of the core InfraWorks set of tools, and one is from the Drainage Design tools.

Surface Layers Surface Layers is a core InfraWorks 360 command. Surface layers are the parts of the model that rest on the ground. This icon opens a panel that lets you manage the visibility of these objects.

Profile View This tool opens the Profile View panel, which has the primary purpose of viewing and editing road designs. However, you can also see markers indicating drainage components.

Surface Opacity This is a core InfraWorks 360 feature. It is a handy toggle that switches your terrain surface from see-through to opaque. It is great for working on underground features such as culverts or drainage networks.

Point-To-Point Distance This is a core InfraWorks 360 feature. You use it to measure a straight-line distance by picking two points in the model.

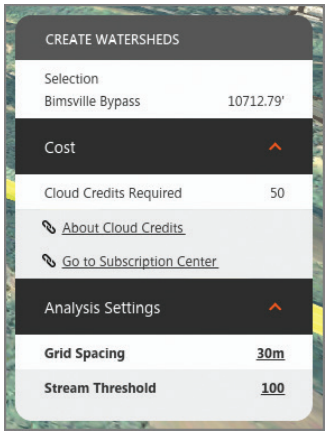
Path Distance This is a core InfraWorks 360 feature. You use it to measure the distance along a path by picking multiple points in the model.

Terrain Statistics This is a core InfraWorks 360 feature. You use it to get information about an area of terrain such as area, volume, and other data. You can also get data about how a coverage is modifying existing terrain such as cut, fill, and other design information.

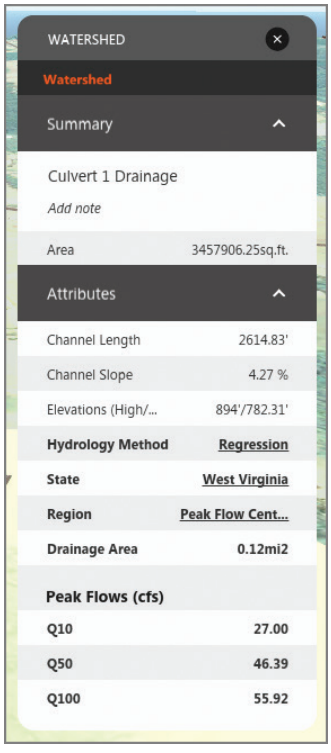
Drainage Design Asset Cards

Eight new asset cards come along with Drainage Design for InfraWorks 360: Create Watersheds, Watershed, Culvert, Quantities, and four Drainage Network asset cards. You will study these in greater detail in Chapter 2 “Working with Watersheds and Culverts.”

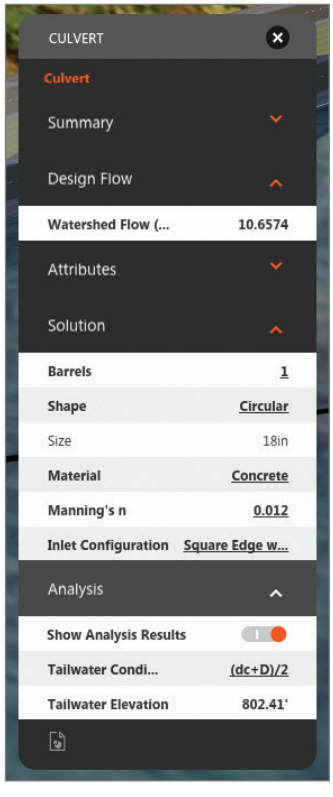
Create Watersheds The Create Watershed asset card is used to configure key settings before submitting your watershed analysis for processing in the cloud. It also displays information and provides links relating to cloud credits.



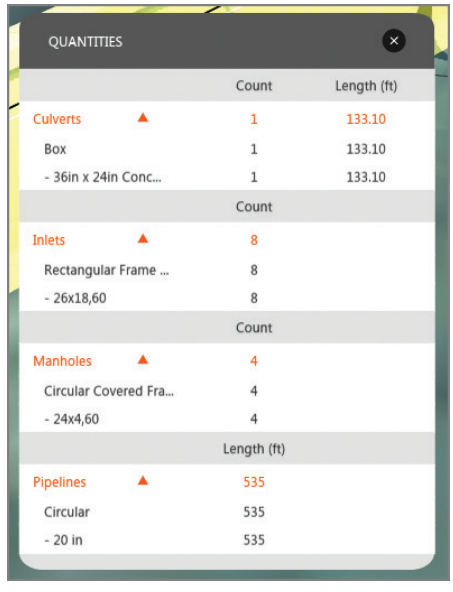
Watershed The Watershed asset card is used for reporting information to you as well as configuring the watershed for hydrologic analysis. From here, you can view information about the area, elevations, and slopes of the watershed as well as choose a calculation method, assign key values, and ultimately calculate flows.



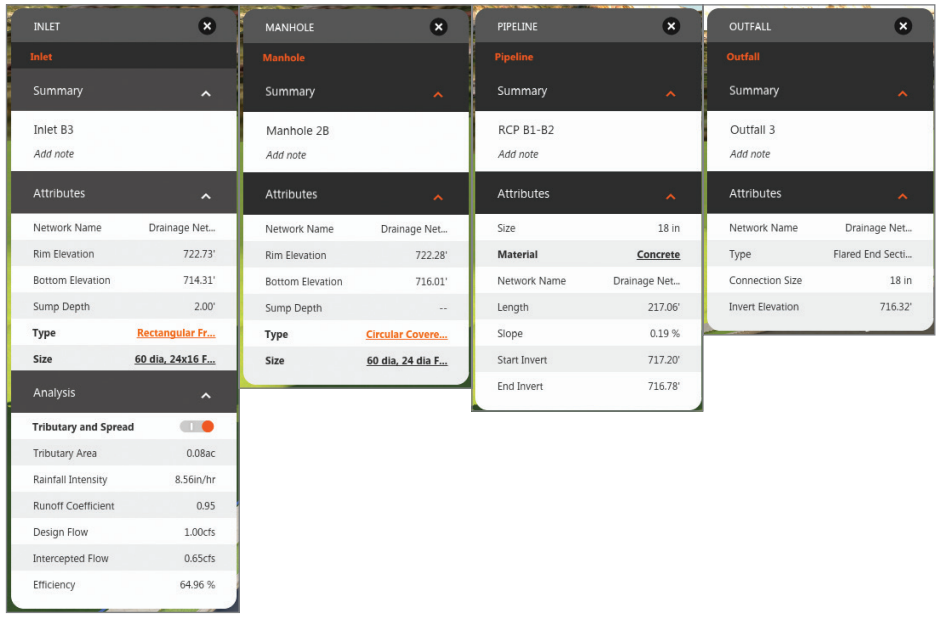
Culvert The Culvert asset card provides you with full design capabilities for a culvert while providing simultaneous analysis. Here you can choose the culvert shape, number of barrels, inlet configuration, and other important design features. You can also define the tailwater condition and elevation, and toggle the graphical view of the culvert analysis.



Quantities The Quantities asset card reports quantities of culverts, inlets, manholes, and pipelines for a design road that you choose. No information can be edited on this asset card.



Drainage Network The four drainage network asset cards (Inlet, Manhole, Pipeline, and Outfall) report information about the drainage network component you have selected. In some cases, they allow you to make modifications.



Right-Click Commands

With Drainage Design for InfraWorks 360 enabled, you will find some additional commands in several right-click menus. These additions are covered next.

Roads

When you right-click a road while in edit mode, you will see four commands that relate to drainage design (see Figure 1.16).

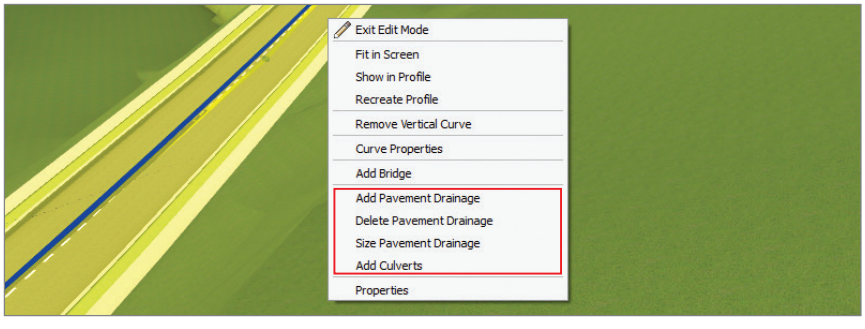


FIGURE 1.16 The additional drainage commands are within the red box.

Add Pavement Drainage This command automatically adds inlets, manholes, pipelines, and outfalls along the design road based on design rules and engineering assumptions. You can edit the network once it is created. This command appears only if the road has curbs.

Delete Pavement Drainage This command deletes all inlets, manholes, pipelines, or outfalls that are part of a drainage network associated with the design road.

Size Pavement Drainage This command sizes the pipes in the network based on estimated flows and other assumptions.

Add Culverts This command analyzes the road and inserts a culvert wherever the road crosses a water area or stream. The culvert will remain associated with the road and the water feature that it crosses. It will update automatically as edits are made.

Culverts

When you right-click a culvert while in edit mode, you will see one command that relates to culverts: Analyze Culvert (see Figure 1.17). This command reassesses aspects that affect the design of the culvert, such as flow or road

geometry. Most of the time, the culvert updates on its own, but this command can be used to manually trigger an update.

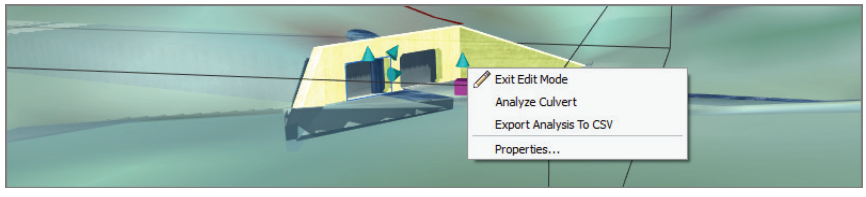


FIGURE 1.17 Right-click menu for culverts

Drainage Network Layout

When you launch the Drainage Network command, you can right-click and choose which components you would like to be inserted as you click points in the model. The choices are Inlets And Pipelines, Manholes And Pipelines, Outfall and Pipeline, Inlets Only, Manholes Only, and Outfalls Only (see Figure 1.18).

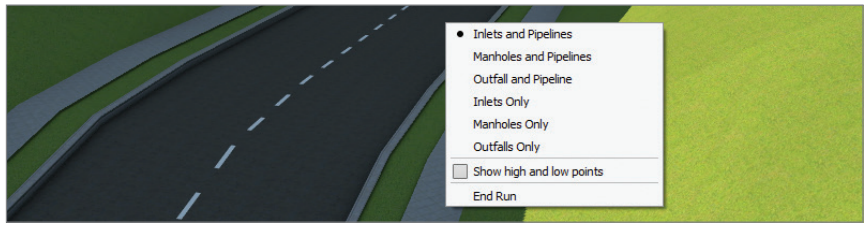


FIGURE 1.18 The right-click menu available while laying out pavement drainage

Drainage Properties

With Drainage Design for InfraWorks 360 enabled, you will experience the addition of several new InfraWorks 360 objects such as culverts, watersheds, and streams. These objects will have their own unique properties in addition to the "generic" properties that all InfraWorks 360 objects have. Drainage network components are still classified as pipelines and pipeline connectors, but they do possess some differences when compared with those objects created with basic InfraWorks tools. Figure 1.19 shows the properties of a watershed, which you can see has unique values such as those shown in the Watershed section.

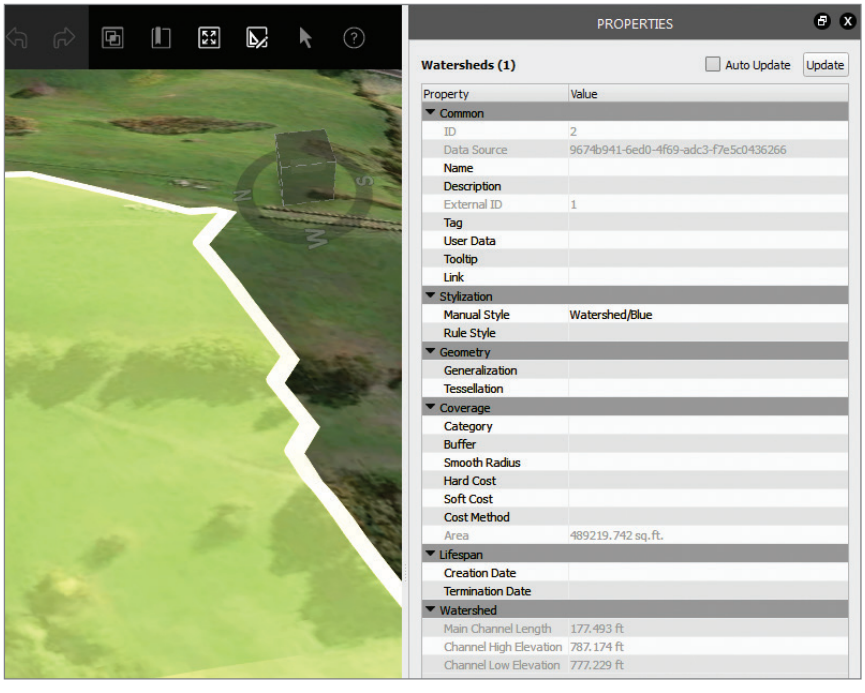


FIGURE 1.19 The properties of a watershed

Exercise 1.1: Explore Drainage Design for InfraWorks 360

To begin this exercise, go to the book's web page at `www.sybex.com/go/drainagedesignessentials2e` and download the files for Chapter 1. Using the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.

2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 01\` and select `Ch01 Bimsville Drainage.sqlite`. Click Open.

   You are looking at a model of the Bimsville Bypass project. If you have worked through the book *Autodesk® InfraWorks® 360 and Autodesk® InfraWorks® 360 LT Essentials*, then you are quite familiar with this project. In this version of the model, only a portion of the bypass has been created, and only the roads for the industrial park are in the model.
4. If the Ex_1_1 proposal is not already current, click the Proposals drop-down list on the Utility Bar and select it, as shown in Figure 1.20.

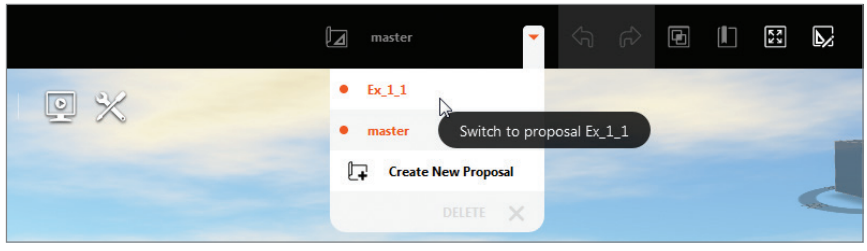


FIGURE 1.20 Selecting the correct proposal

5. Click the Bookmarks icon on the Utility Bar; then click Watershed 1 to restore that bookmark.

   You are looking at a location where a watershed is shown that feeds a small stream that crosses the Bimsville Bypass. This watershed was generated using the Create Watersheds command.

6. Click within the shaded area representing the watershed. The Watershed asset card should open, as shown in Figure 1.21.

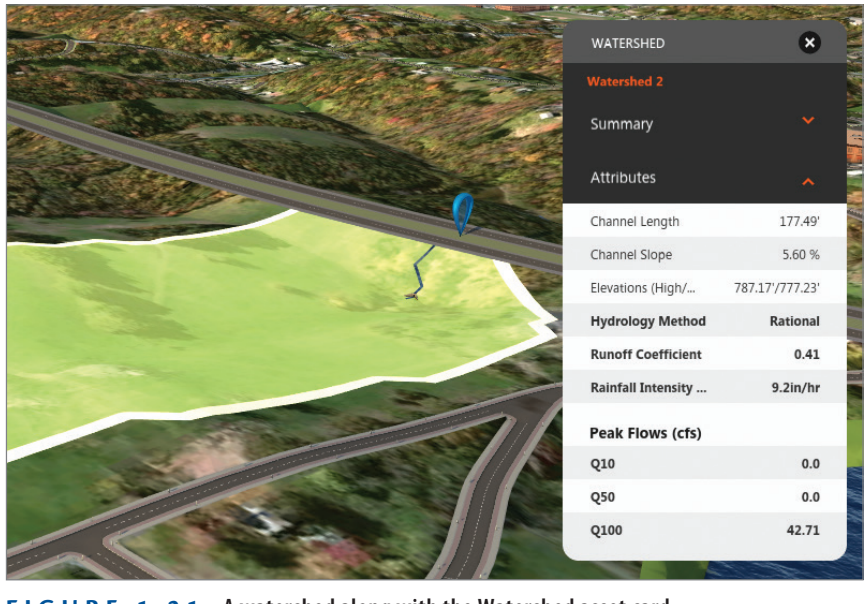


FIGURE 1.21 A watershed along with the Watershed asset card

Scan some of the information shown in this asset card; note that a peak flow has been calculated for the Q100 value.

7. Press Esc to clear the selection and close the asset card. Restore the bookmark named Culvert 1.

   You are looking at one end of a culvert created beneath the Bimsville Bypass. This culvert was created using the Add Culverts command on the road right-click menu.

8. Click the culvert to open the Culvert asset card.

9. In the Analysis section of the Culvert asset card, click the switch next to Show Analysis Results to turn it on. If it is already on, skip to the next step.

10. Restore the bookmark named Culvert 1 Analysis. You can now see the graphical representation of the culvert analysis hovering above the actual culvert (see Figure 1.22).

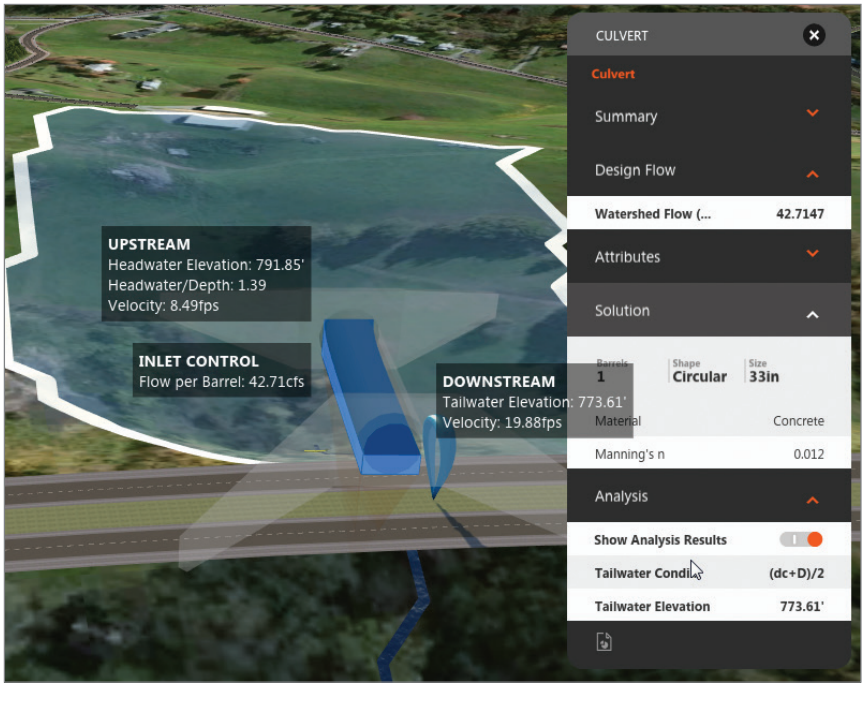


FIGURE 1.22 The graphical analysis of a culvert along with its asset card

11. Press Esc to clear the selection of the culvert, close the analysis, and close the asset card. Restore the bookmark named Pavement Drainage.

    You are now viewing two inlets, a manhole, and an outfall that have been placed on a two-lane design road. If you are familiar with any of the other InfraWorks Essentials books, you may recognize that this road is part of the industrial park development.

12. Restore the bookmark named Pavement Drainage Underground.

    From an underground vantage point, you are now viewing the same structures along with pipelines (see Figure 1.23).

If you are unable to navigate underground, make sure that the Lock Mouse Navigation Above Ground option is turned off in the Application Options dialog, Navigation view.

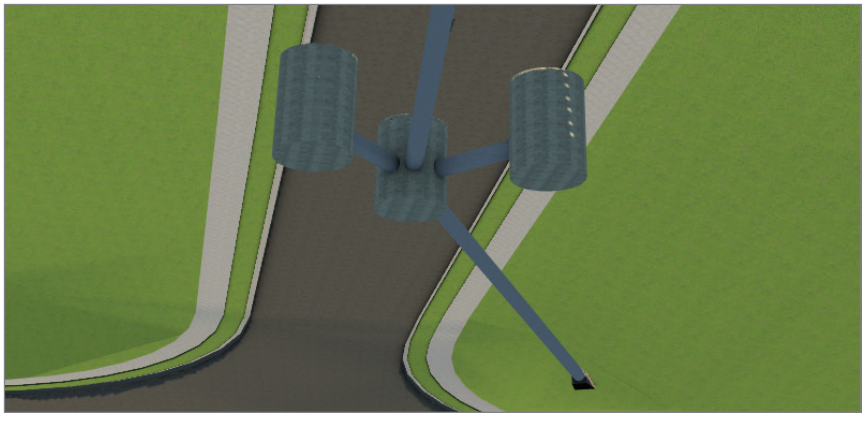


FIGURE 1.23 An underground view of a drainage network

13. Restore the bookmark named Inlet.

    You are looking at a close-up view of an inlet and a portion of the road that slopes toward this inlet.

14. Click the inlet to select it and open the Inlet asset card. If it is not already on, click the slider for Tributary and Spread to turn it on.

    As shown in Figure 1.24, you should see a blue outline showing the inlet's tributary area as well as blue shading representing the spread of the flow of water leading to the inlet.

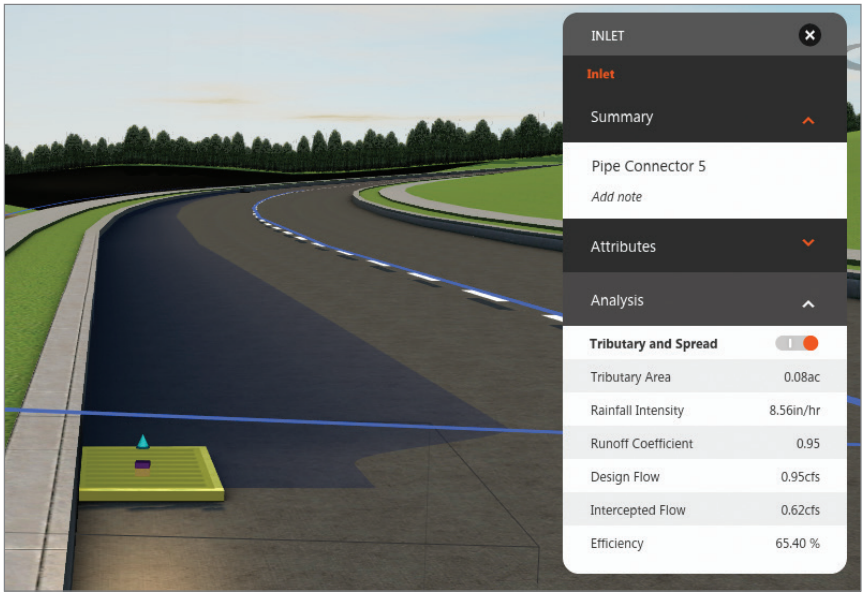


FIGURE 1.24 An inlet along with its tributary area, spread graphic, and Inlet asset card

Spread the Word

You may be unfamiliar with the concept of inlet *spread*. During a rain storm, think of water flowing along the curb as kind of stream. Spread is one way of assessing the performance of an inlet and determining how much of this stream drops into the inlet (*intercepted flow*) and how much of it travels beyond the inlet (*bypass flow*). Spread calculations also include the width and depth of the stream, and as a designer, you may need to assess whether those dimensions are acceptable for a given inlet.

15. On the Inlet asset card, click the orange bold text next to Type. If this text is not orange, click the Edit icon on the Utility Bar.
    The Select Component asset card opens.
16. Scroll down and observe the many types of inlets that are available in the Select Component asset card.

The InfraWorks 360 library has an extensive set of inlets from which to choose.

17. Press Esc to clear the selection of the inlet and close all asset cards.

Now You Know

Now that you have completed this chapter, you understand the capabilities of Drainage Design for InfraWorks 360. You know that it runs in InfraWorks 360 software and extends its functionality by providing tools for watershed analysis, culvert design, and drainage network design. You also understand what Drainage Design for InfraWorks 360 adds to the InfraWorks 360 user interface. This includes several new intelligent tools, asset cards, and right-click commands. This also includes some additional properties that you can view and modify in the Properties panel.

After completing this chapter, you should be comfortable navigating within Drainage Design for InfraWorks 360, and you're ready to begin using it to perform some serious drainage design.

CHAPTER 2

Working with Watersheds and Culverts

Now that you've familiarized yourself with Autodesk® Drainage Design for InfraWorks® 360 and are aware of its capabilities, you are ready to begin performing your own analyses and designs. As you'll learn in this chapter, the technology that enables you to design and analyze drainage in the InfraWorks 360 software is quite powerful but also relatively simple to use. In this chapter, you'll look at several topics that relate to drainage design and analysis.

In this chapter, you'll learn to

- **Create watersheds**
- **Analyze watersheds**
- **Design culverts**
- **Analyze culverts**

Working with Watersheds

In this section, you will study the use of Autodesk® InfraWorks® 360 software to create and analyze watersheds. I'll start with a discussion of the "science" of watersheds, what they are, and why they're important when performing drainage analysis and design. Then I'll show how to create watersheds and finish up with how to analyze watersheds to determine predicted peak flows.

Understanding Watersheds

A watershed is an area that drains to a specific location such as a culvert entrance, inlet opening, bridge opening, stream, river, pond, or lake (see Figure 2.1).

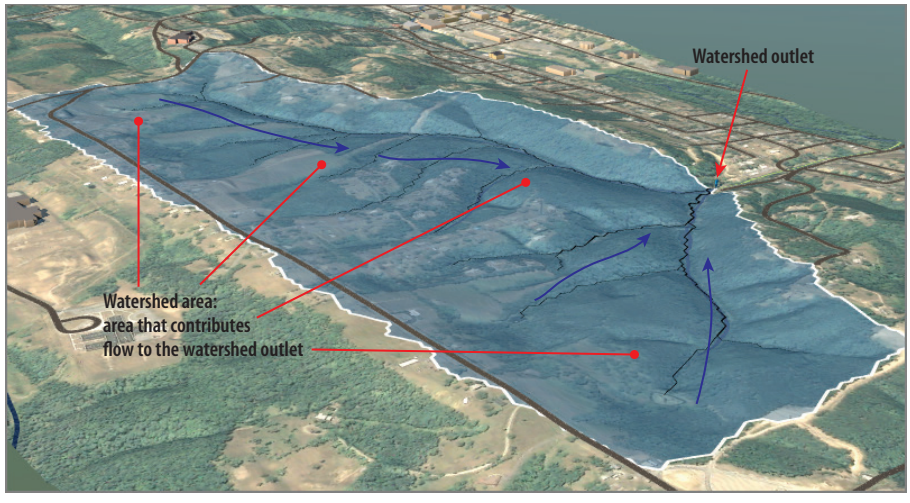


FIGURE 2.1 An example of a watershed

Several important characteristics of the watershed determine the amount of flow that will leave the watershed and enter the location of interest. Of these characteristics, the one that is easiest to understand is area. The larger the area is that a watershed covers, the more flow it will contribute to the location of interest. The second characteristic is the amount of water that will flow across the ground surface compared to what will be absorbed. Many factors—such as the soil type, the topography, and the nature of the ground surface—impact this characteristic: pavement versus grass versus forest, for example. Since these characteristics can vary across a given watershed, either assumptions must be made or a detailed analysis must be performed to predict how readily the watershed will absorb water. This is usually expressed in some sort of runoff factor.

The shape and area of a watershed are determined by the topography and possibly man-made structures such as walls, dams, channels, and so on. Generally speaking, the highest points in a watershed form the outer boundary, and the lowest point is the location where runoff exits the watershed. In addition, the direction that the land slopes has a direct effect on the direction that runoff flows. To delineate a watershed, the terrain must be analyzed to find these ridge lines and low points and determine the directions of slopes.

Creating Watersheds

As you might guess, the terrain analysis described in the previous section is rather intense and requires intense calculation, the type that is done with ample computing power. Because most individuals do not possess computers with this amount of power, the InfraWorks 360 watershed functionality looks to the cloud to perform its tasks. To start the process, you click the Create Watersheds icon on either the Analysis toolbar (see Figure 2.2) or the Design toolbar of the Drainage Design tools.

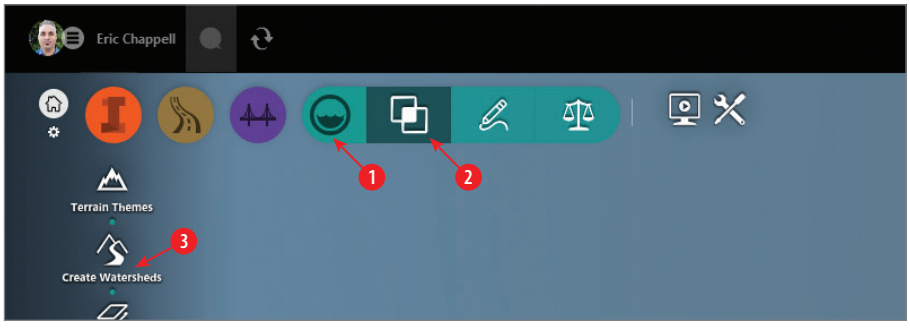


FIGURE 2.2 You can click the icons in the order shown to create one or more watersheds.

Once you have launched the tool, you can either click a design road or click a point in the model that is not on a design road. If you click a design road, you can either press Enter to analyze the entire road or pick two points along the road to confine the analysis to a region of the road (see Figure 2.3). If you pick a point on the model that is not on a road, you can simply begin the analysis by pressing Enter.

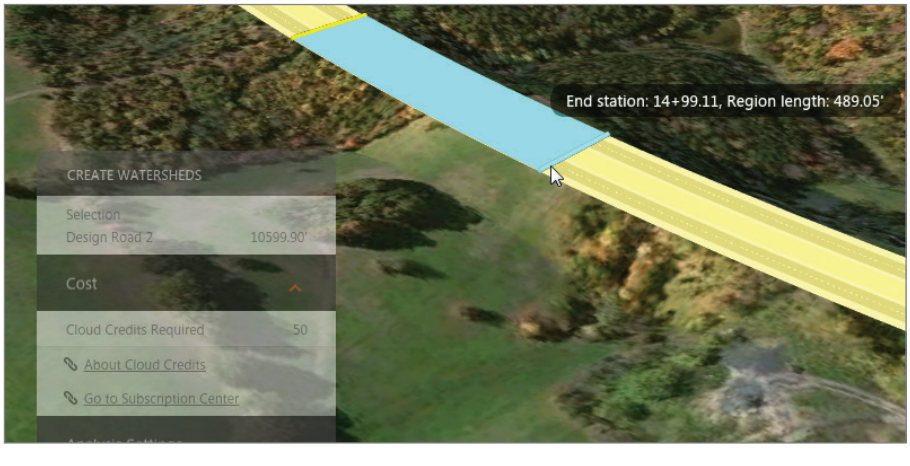


FIGURE 2.3 Defining a region on a design road for watershed analysis

When you launch the Create Watersheds command, the Create Watersheds asset card will open (see Figure 2.4). You can modify the applicable values on this asset card at any time before pressing Enter to start the analysis process. The first two sections of the asset card simply report what you have selected and what the cost will be in cloud credits. Neither of the values in these two sections can be modified. The Analysis Settings section contains two values that you will want to address. The first is Grid Spacing, and the second is Stream Threshold.

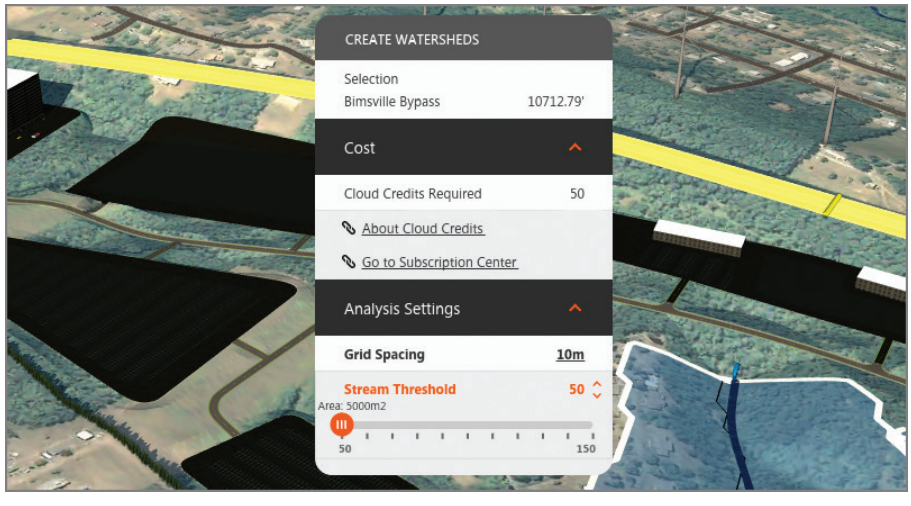


FIGURE 2.4 The Create Watersheds asset card

Grid Spacing Your terrain will be analyzed by first subdividing it into grid squares that have a constant slope. These grid squares become the "units" of the analysis. The limits of the watershed and the paths of the streams will be drawn along the edges of these grid squares. The smaller you make these squares, the more accurate your analysis will be—but at the expense of computing time and possibly model performance. Therefore, choose a value that is appropriate for the size of your project and the accuracy that is required. The value ranges from 10 meters to 50 meters. (There is no Imperial equivalent for this.)

Stream Threshold This value sets the number of grid squares used to define streams. For example, a Stream Threshold of 50 means that a stream is created once there are 50 grid squares contributing flow to its starting point. As you set the value for Stream Threshold, you will see an area value reported at the left end of the slider. So, for example, if Grid Spacing is set to 10 meters and Stream Threshold is set to 50, then the area will be 5,000 square meters, the equivalent of fifty 10×10 squares. In other words, a smaller value here will generally produce longer, more numerous streams, and a larger one will produce fewer streams that are shorter. The value for Stream Threshold can range from 50 to 150.

Cloud Credits?

Certain functions in InfraWorks 360 require the use of cloud credits, and the Create Watersheds command is one of them. Cloud credits must be purchased by you or your company and allocated by an account administrator. If you are the sole owner of your software, then that is you. If you work for a company or organization, you may need to request to have cloud credits allocated to your account.

Once you have selected your point, road, or road region, and you have configured the Create Watersheds asset card to your requirements, you can press Enter to begin the analysis process. InfraWorks 360 will prepare the necessary data, upload it to the cloud, process the data, and finally generate your results in the model in the form of one or more watersheds, stream networks, and points of interest indicating outlet points or points where streams cross design roads. You will see these items listed on the Data Sources panel (see Figure 2.5), where they can be managed like any other data source you have learned about. Also, at the end of the process, InfraWorks 360 will report how many cloud credits were deducted from your account as a result of the analysis.

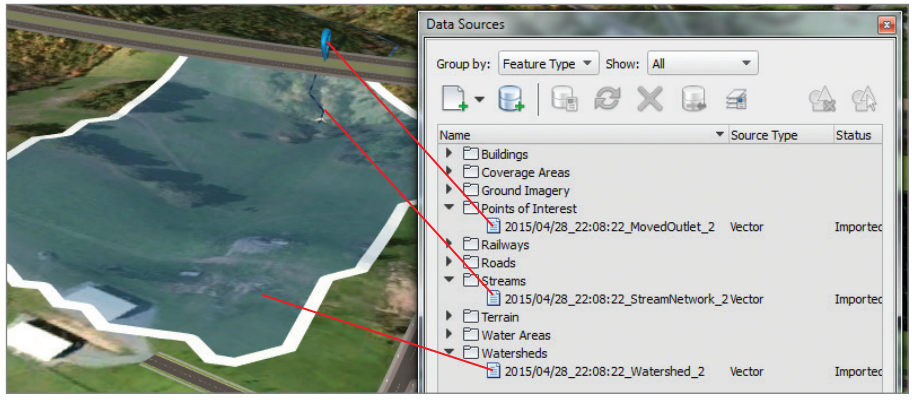


FIGURE 2.5 A watershed, stream, and point of interest shown in the model as well as in the Data Sources panel

Exercise 2.1: Create a Point Watershed

In this exercise, you will create a watershed that drains to the location of a future culvert. You will indicate the location of the culvert entrance and allow InfraWorks 360 to calculate the watershed limits.

To begin this exercise, go to the book's web page at `www.sybex.com/go/drainagedesignessentials2e` and download the files for Chapter 2. Following the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.
2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 02\` and select `Ch02 Bimsville Drainage.sqlite`. Click Open.
4. If the Ex_2_1 proposal is not already current, select it from the Proposals drop-down menu.
5. Click the Bookmarks icon on the Utility Bar; then click Point Watershed to restore that bookmark.

   You are looking at a location where the embankment of the industrial park road is obstructing the natural flow of water in a small valley (see Figure 2.6). As a designer, you may want to place a culvert entrance at this location to allow the flow to continue beneath the road. To design that culvert, you will need to calculate the flow to its entry point. In the upcoming steps, you will create a watershed for this location so that this flow can eventually be calculated.

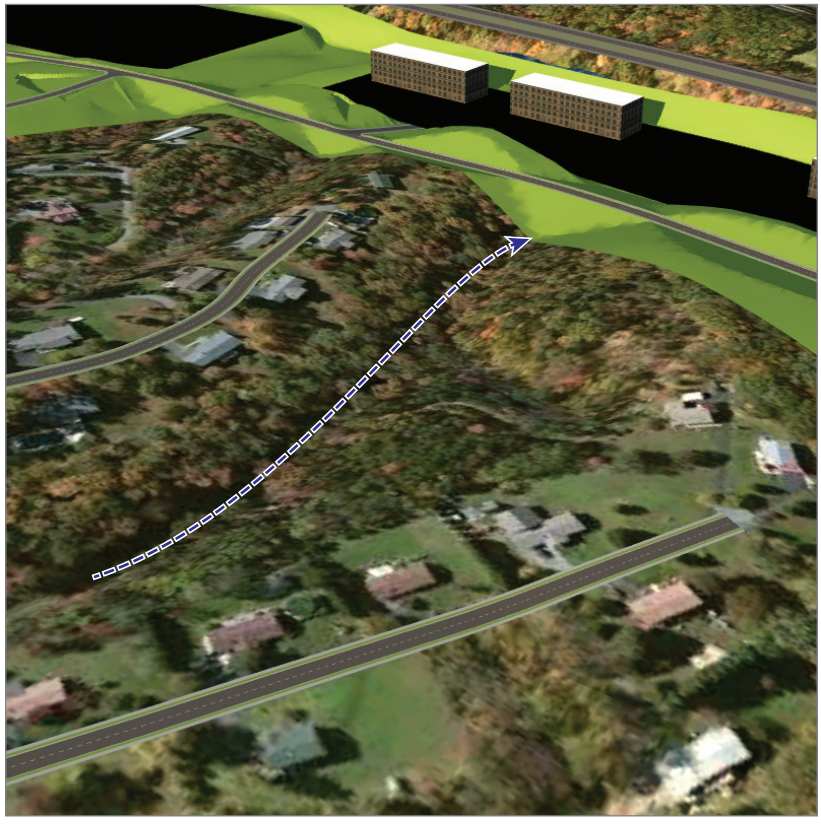


FIGURE 2.6 A design road is obstructing the flow of water.

6. Click the Drainage icon on the main toolbar to expand the Drainage toolbar.

7. Click the Design icon on the Drainage toolbar.

8. Click Create Watersheds on the Design toolbar. If a dialog opens informing you that an Internet connection and InfraWorks 360 account are required, click OK.

   The Create Watersheds asset card will open, and a prompt will appear at the bottom of the screen, instructing you to click an outlet point or select a design road.

9. Click a point in the model at the low point where the road embankment meets the bottom of the valley. The location of this point would be near the tip of the blue arrow in Figure 2.6.

If you do not have access to cloud credits or if there is some issue with the setup of your InfraWorks 360 account, you may hit a roadblock here. If so, just skip this step and the next one, and restore the Ex_2_1_End proposal to see the results.

A blue point of interest will be inserted at the location you picked, as shown in Figure 2.7.

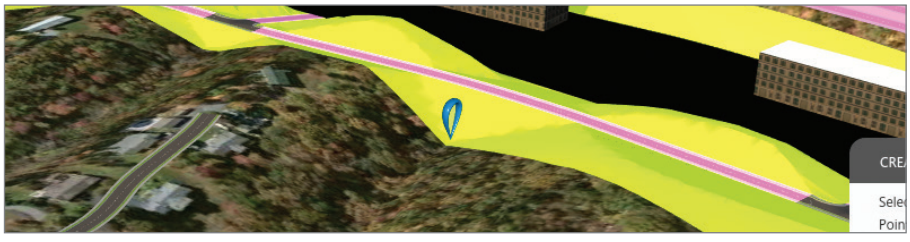


FIGURE 2.7 A point of interest is inserted to mark the outlet point for a watershed.

10. On the Create Watersheds asset card, set Grid Spacing to 10m and Stream Threshold to 50. Press Enter.

You will see a series of notifications as the process takes place:

- Preparing data
- Uploading data to cloud
- Running watershed analysis on cloud
- Downloading watershed analysis results from cloud
- Generating watersheds and stream networks

If you open the Data Sources panel, you will see new entries under Streams and Watersheds.

This process should take only about a minute, but the length of time will vary based on your computer speed and Internet connection. When the process is complete, you will see the watershed, stream network, and point of interest appear in the model. In addition, a dialog will inform you that the analysis request completed successfully along with information about the number of cloud credits utilized for the analysis.

11. Click OK to dismiss the notification dialog. Zoom out and observe the extent of the watershed that has been created.

The watershed clearly delineates the area that drains to this outlet point (see Figure 2.8). Later you'll use this watershed to design a culvert with an entrance that will be placed at the outlet point.

You can view the results of successfully completing this exercise by selecting the Ex_2_1_End proposal.

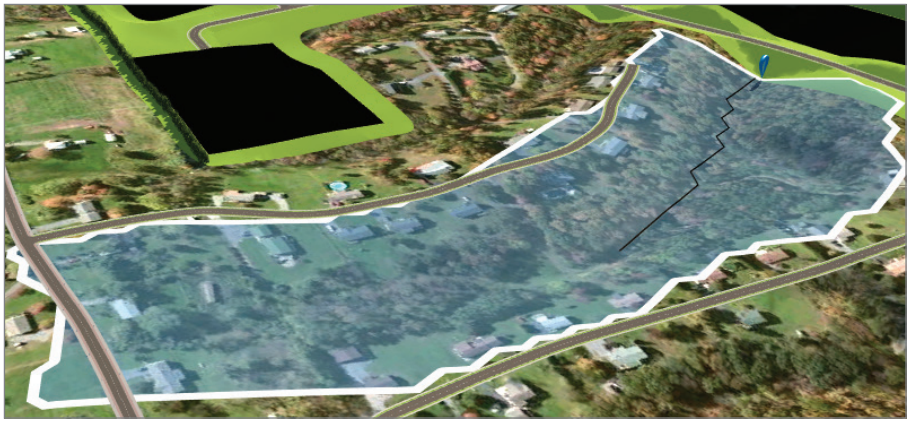
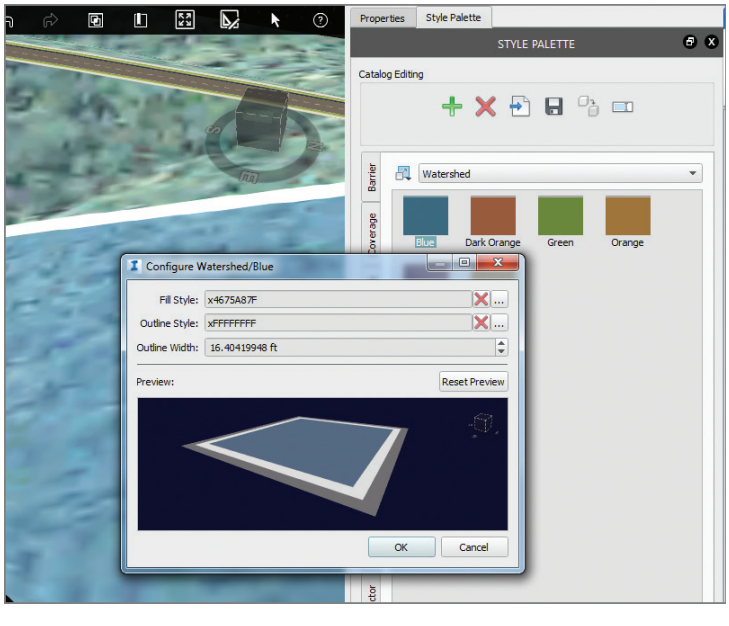


FIGURE 2.8 The full extent of the watershed

Watershed Styles

Watersheds have their own styles, and you'll see a separate tab for them on the Style Palette. They are configured exactly like coverage styles, which is by selecting a material for Fill Style and a material for Outline Style and by specifying a value for Outline Width.



Exercise 2.2: Create Road Watersheds

In this exercise, you will choose a region of the Bimsville Bypass and allow InfraWorks 360 to automatically locate outlet points along the road as well as delineate watersheds and stream networks.

If you are continuing from the previous exercise, you can skip to step 4. Otherwise, if you haven't already done so, go to the book's web page at `www.sybex.com/go/drainagedesignessentials2e` and download the files for Chapter 2. Using the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.
2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 02\` and select `Ch02 Bimsville Drainage.sqlite`. Click Open.
4. Select Ex_2_2 from the Proposals drop-down menu.

5. Click the Bookmarks icon on the Utility Bar; then click Road Watersheds to restore that bookmark.

   You are looking at a location where a portion of the Bimsville Bypass is in a fill condition and appears to be obstructing several valleys, which may carry the flow of water (see Figure 2.9).

6. If the Drainage toolbar is not visible, click the Drainage icon on the main toolbar to expand the Drainage toolbar.

7. If the Design toolbar is not visible, click the Design icon on the Drainage toolbar.

8. Click Create Watersheds on the Design toolbar. If a dialog opens, informing you that an Internet connection and an InfraWorks 360 account are required, click OK.

   The Create Watersheds asset card will open, and a prompt will appear at the bottom of the screen, instructing you to click an outlet point or select a design road.

9. Click a point on the Bimsville Bypass, the four-lane divided highway running left to right across the top of your view.

If you do not have access to cloud credits or if there is some issue with the setup of your InfraWorks 360 account, you may hit a roadblock here. If so, just skip this step and the next one, and restore the Ex_2_2_ End proposal to see the results.

FIGURE 2.9 A design road is obstructing the flow of water.

You will be prompted to select a region. As you move your cursor, a yellow cylinder gizmo will follow it, and a tooltip will report the station.

10. Click a point on the road such that the station value reported on the tooltip is roughly 14+00 (0+425).

    You will be prompted for the second station, and a blue cylinder gizmo will follow your cursor while the yellow one will remain at the location of the first click.

11. Click a point near station 19+00 (0+575), as shown in Figure 2.10.

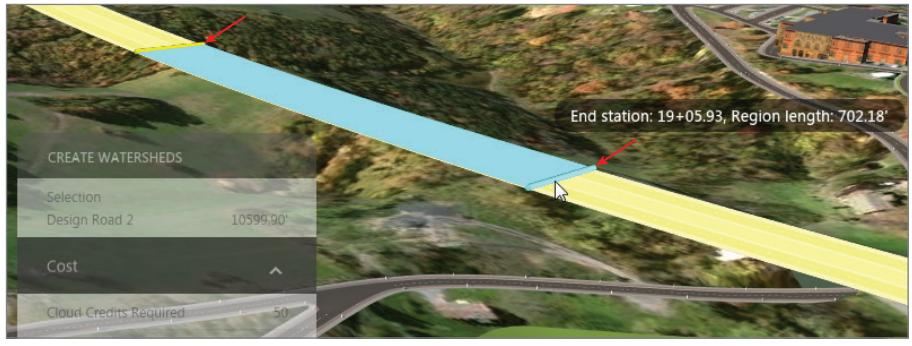


FIGURE 2.10 **Choosing the region of a road for a watershed analysis (the red arrows highlight the start and end of the region)**

12. On the Create Watersheds asset card, set Grid Spacing to 10m and Stream Threshold to 50. Press Enter.

    You will see a series of notifications as the process takes place:

    - Preparing data
    - Uploading data to cloud
    - Running watershed analysis on cloud
    - Downloading watershed analysis results from cloud
    - Generating watersheds and stream networks

    This process should take only about a minute, but the length of time will vary based on your computer speed and Internet connection. When the process is complete, you will see one watershed, one stream network, and a point of interest appear in the model. In addition, a dialog will inform you that the analysis request completed successfully along with information about the number of cloud credits utilized for the analysis.

13. Click OK to dismiss the notification dialog. Zoom out and observe the extent of the watershed that has been created.

    Although there were at least two potential outlet points within the range you selected, only one generated a watershed and a stream network (see Figure 2.11). Other potential areas did not possess the required 5,000 square meters of upstream contributing area to generate a stream network and, therefore, a watershed.

    You can view the results of successfully completing this exercise by selecting the Ex_2_2_End proposal.

In the Data Sources panel, you will see new entries beneath Streams and Watersheds and a new category for Points Of Interest with its own new entry.

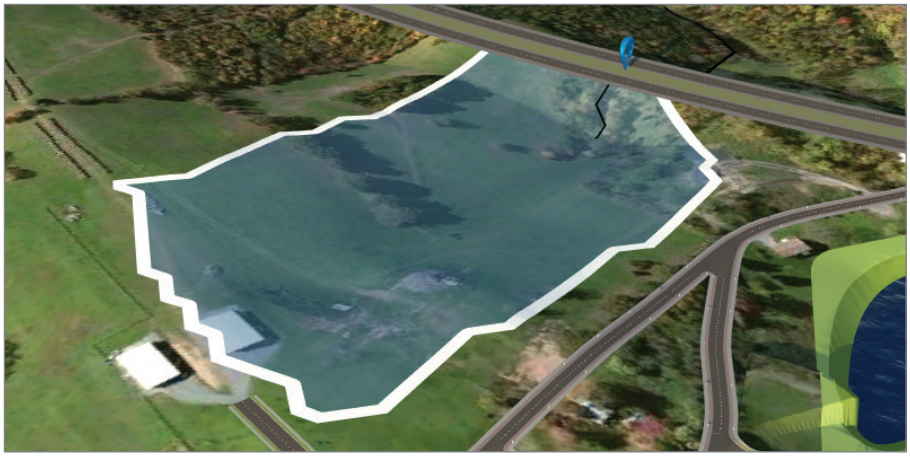


FIGURE 2.11 A single watershed is generated by the analysis.

Analyzing Watersheds

Once you have used Drainage Design for InfraWorks 360 to create a watershed in your model, it is fairly easy to calculate one or more peak flows for that watershed. To accomplish this, you use the Watershed asset card (see Figure 2.12) to configure the analysis and report the results.

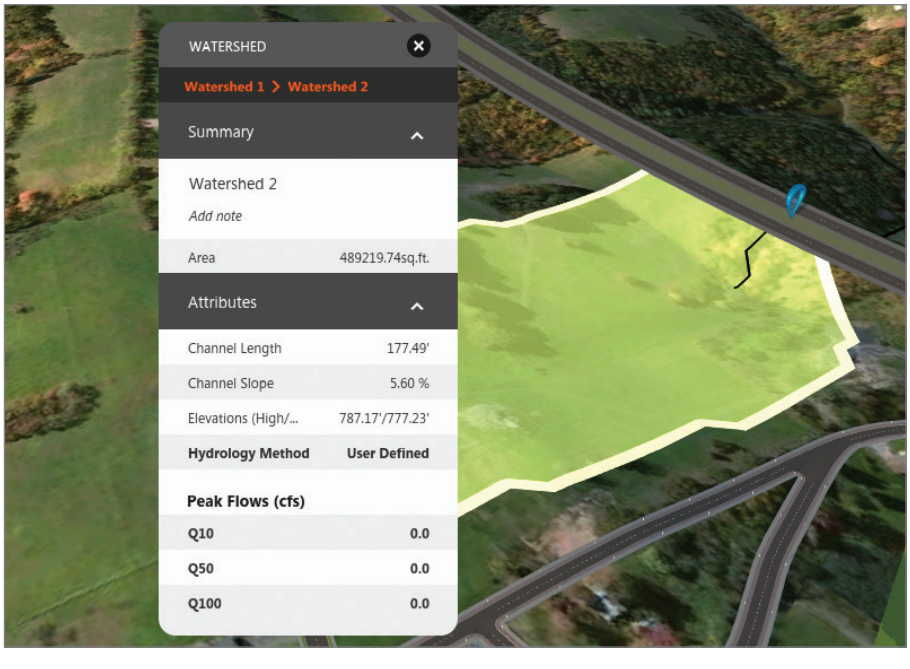


FIGURE 2.12 The Watershed asset card

The Summary section of the Watershed asset card contains general information such as the watershed name, notes, and area. You can edit the name and notes, but the area is derived from the watershed object and cannot be edited.

The Attributes section is where the analysis is configured, and the results are reported in the form of peak flows. The first few values—Channel Length, Channel Slope, and Elevations (High/Low)—are calculated automatically by the software and cannot be modified. These are key values in determining the peak flow when you choose the Rational Method or the Regression Method. The next few options will vary based on which method you select.

Hydrology Method: User Defined Select User Defined when you want to use flow values that you've calculated outside InfraWorks 360 or for times when you want to apply some "educated guesses" based on what you already know about the region and the site (see Figure 2.13).

FIGURE 2.13 A sample User Defined analysis

When you choose this method, you can enter your predetermined values for Q10, Q50, and Q100. The Q100 flow will be used to size culverts.

Hydrology Method: Rational The Rational Method is a commonly used method based on the characteristics of the land and historical rainfall data (see Figure 2.14).

FIGURE 2.14 A sample Rational analysis

The following options are available when you choose this method:

Runoff Coefficient The runoff coefficient is a value between 0 and 1, which is lower for pervious land cover (forest) and higher for impervious (pavement and rooftops).

Rainfall Intensity The rainfall intensity is most commonly obtained from an intensity-duration-frequency (IDF) curve that has been developed for the area within which the project resides. It represents the amount of rainfall that is expected based on historical values.

Peak Flows Only the Q100 value is provided when the Rational Method is chosen. It is calculated automatically and cannot be edited.

Hydrology Method: Regression The Regression Method calculates flow using a regression equation. Studies have been done to derive regression equations that predict peak flows for specific regions. When you use this method, which applies only to the United States, you must choose the state and region your project is located within (see Figure 2.15).

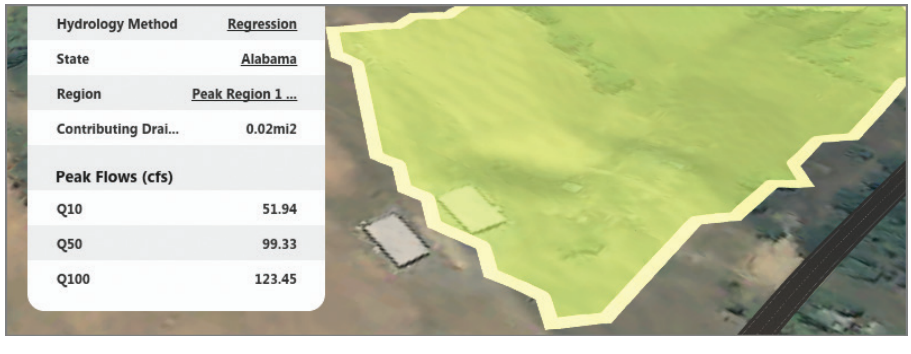


FIGURE 2.15 A sample Regression analysis

The following are some of the options available when you choose this method. Additional options may appear, depending on which state you select.

State Choose the state within which your project resides.

Region Choose a region within the state. The number and names of the available regions will vary based on the state you have chosen.

Contributing Drainage Area This value is derived automatically based on the watershed itself. It cannot be edited.

Peak Flows Q10, Q50, and Q100 values are all provided. These values are calculated by the software and cannot be edited.

Exercise 2.3: Analyze Watersheds

In this exercise, you will provide user-defined flows for the industrial park watershed and use both the Rational Method and the Regression Method to analyze the Bimsville Bypass watershed.

If you are continuing from the previous exercise, you can skip to step 4. Otherwise, if you haven't already done so, go to the book's web page at `www.sybex.com/go/drainagedesignessentials2e` and download the files for Chapter 2. Following the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.
2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 02\` and select `Ch02 Bimsville Drainage.sqlite`. Click Open.

4. Select Ex_2_3 from the Proposals drop-down menu.
5. Click the Bookmarks icon on the Utility Bar; then click Point Watershed to restore that bookmark.

   You are viewing a watershed that drains to the future location of a culvert. Let's say that since this design is taking place adjacent to a local road, the design standards are a bit less defined, and you can simply plug in some estimated flows.
6. Click the watershed to reveal the Watershed asset card.
7. In the Attributes section, for Hydrology Method, select User Defined.
8. For the Q10, Q50, and Q100 values under Peak Flows, enter **10** (**0.28**), **15** (**0.42**), and **20** (**0.57**), respectively, as shown previously in Figure 2.12.

   These values will be stored in the software and remain associated with this watershed. Later you will create a culvert at this location, and it will associate itself with the Q100 value.

If you are unable to edit this value, right-click the watershed and select Edit to enter edit mode.

9. Restore the Road Watersheds bookmark. Click the watershed in this area to open the Watershed asset card.

10. On the Watershed asset card, do the following:

    - For Hydrology Method, choose Regression.
    - For State, choose West Virginia.
    - For Region, choose Peak Flow Eastern Panhandle Region 2010 5033.

    Note the flows that are calculated (see Figure 2.16).

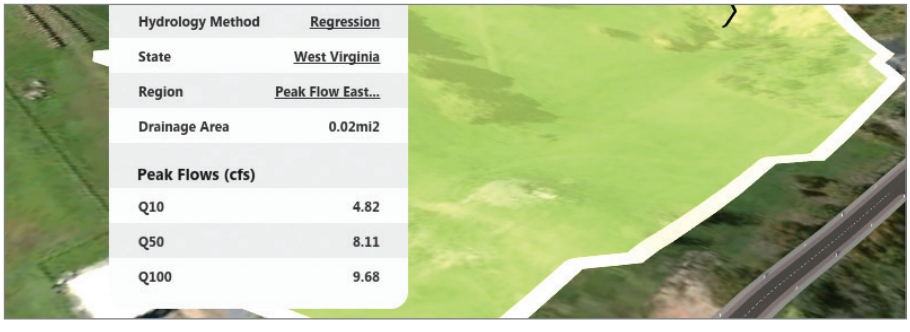


FIGURE 2.16 The results of a Regression analysis

11. On the Watershed asset card, do the following:

    - For Hydrology Method, choose Rational.
    - For Runoff Coefficient, enter **0.27**.
    - For Rainfall Intensity, enter 8 **(203)**.

    Note the flows that are calculated (see Figure 2.17). Based on these results, the Rational Method results yield higher flows than the Regression Method results. Perhaps for additional safety, when you design the culvert later, you should consider using the more conservative Rational Method results.

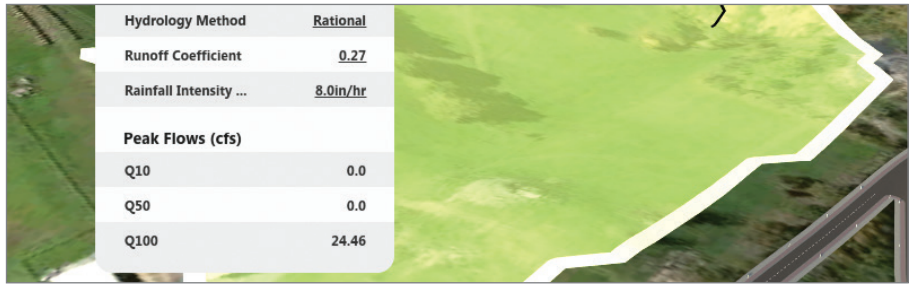


FIGURE 2.17 The results of a Rational analysis

You can view the results of successfully completing this exercise by selecting the Ex_2_3_End proposal.

How Good Are the Numbers?

Remember that InfraWorks 360 is a tool for preliminary conceptual design. The methods applied to delineate watersheds and calculate flows produce an approximation, not a final determination. When you enter the detailed design stages of your project, you will perform these calculations in much more detail with different tools, such as the Storm and Sanitary Analysis or Hydraflow tools that come with Civil 3D© software. However, the information that InfraWorks 360 does provide is useful for getting key information quickly and making big decisions early in a project. For example, a quick watershed analysis may determine whether a bridge is needed or a culvert, which is a big cost difference that may determine feasibility, the path of a road, or the allocation of funding for other purposes. As you have seen, Drainage Design for InfraWorks 360 can provide these key numbers in minutes, which is perfect for a preliminary design or proof of concept. A detailed hydrologic and hydraulic study can take months to prepare, and that is appropriate for the detailed design stage of the project.

Creating Culverts

Using Drainage Design for InfraWorks 360, you can create culverts in two ways. One way is to let the InfraWorks 360 software create the culverts automatically, and the other is to create them manually. You will study both methods in this section.

Creating Culverts Automatically

InfraWorks 360 can create culverts automatically wherever a road crosses a water area (a linear water area, not a closed shape like a pond or lake) or a stream. At first, this may not seem all that impressive until you consider all that is done automatically and the relationships that are established as a result. For example, not only does InfraWorks 360 detect where a water area or stream crosses a road, it also calculates the location where the embankments of the road intersect the stream or water area to determine the exact 3D placement of the culvert inlet and outlet. If a watershed is present at the culvert inlet, InfraWorks 360 will automatically use the Q100 peak flow and size the culvert based on its shape, slope, and other factors. As if that isn't enough, InfraWorks 360 will maintain the relationship between the culvert, location of the road embankments, location of the stream or water area, and peak flow of the watershed. If anything changes, the culvert will be updated automatically. You will learn about manual culvert placement in the next section, but based on everything that was just mentioned, you should seek to have InfraWorks 360 automatically design your culverts whenever possible.

To automatically create culverts, you simply select a design road and right-click it while in edit mode. When you do this, the shortcut menu will contain an Add Culverts command (see Figure 2.18). When you click this command, InfraWorks will insert culverts wherever a stream or water area intersects the road.

FIGURE 2.18 The Add Culverts command

Exercise 2.4: Create a Culvert Automatically

In this exercise, you will have InfraWorks 360 automatically create a culvert beneath the Bimsville Bypass at the location of a previously calculated

watershed. You will then make an edit to the road to observe the dynamic behavior of the culvert.

If you are continuing from the previous exercise, you can skip to step 4. Otherwise, if you haven't already done so, go to the book's web page at `www.sybex.com/go/drainagedesignessentials2e` and download the files for Chapter 2. Following the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.
2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 02\` and select `Ch02 Bimsville Drainage.sqlite`. Click Open.

4. Select Ex_2_4 from the Proposals drop-down menu.
5. Click the Bookmarks icon on the Utility Bar; then click Road Watersheds to restore that bookmark.

   In this version of the model, the stream network was removed, and a more well-defined stream feature was drawn using the Rivers command. This new water feature flows through the valley to a small pond to the southwest of where it crosses beneath the road (see Figure 2.19).

FIGURE 2.19 An existing stream crossing beneath the Bimsville Bypass

6. Click the road to select it; then right-click and select Add Culverts.
   A new culvert will be created that begins where the toe of the eastern embankment meets the stream and ends where the toe of the western embankment meets the stream.
7. Restore the Culvert Upstream bookmark to view the entrance to the culvert (see Figure 2.20).

If you do not see the Add Culverts command, you may not be in edit mode. If that is the case, right-click and select Edit before performing this step.

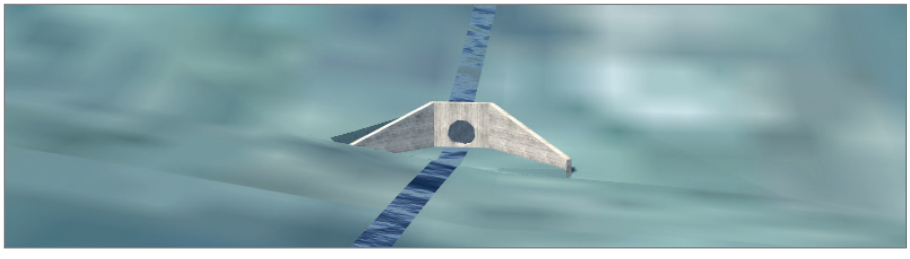


FIGURE 2.20 A view of the upstream end of the culvert

8. Restore the bookmark named Culvert Underground to view the culvert from beneath the road (see Figure 2.21).

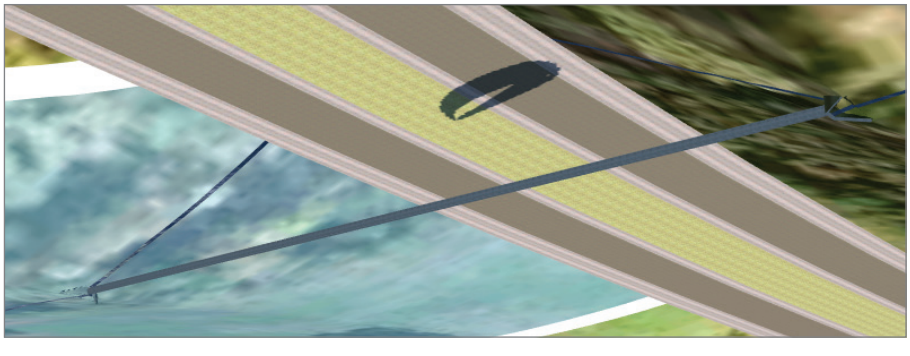


FIGURE 2.21 An underground view of the culvert

Underground View Settings

Viewing from underground works best if you disable the Lock Mouse Navigation Above Ground option and enable the Show Backfaces option. You can find both of these settings in the Application Options dialog in the Navigation and 3D Graphics sections, respectively.

9. Restore the bookmark named Culvert Downstream.

   You are now looking at the downstream end of the culvert. Take note of the location of the culvert exit. You are about to widen the Bimsville Bypass and watch the dynamic behavior as the culvert automatically changes its own design.

10. Click the Bimsville Bypass to open the Road asset card. On the Road asset card, change Edit Mode to Lanes Backward.

11. Change the value for Lanes to 3 and watch as the road widens, the embankment pushes to the west, and the end of the culvert moves westward to match.

    In Figure 2.22, the image on the left reflects two lanes (before), and the image on the right reflects three lanes (after).

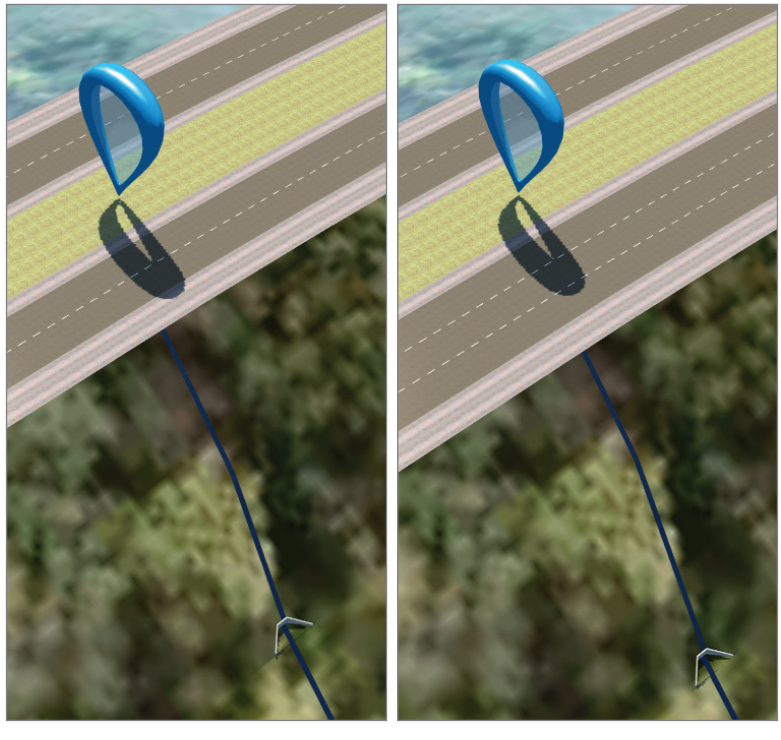


FIGURE 2.22 The culvert has updated its design by shifting the downstream end to match the new embankment location.

You can view the results of successfully completing this exercise by selecting the Ex_2_4_End proposal.

Creating Culverts Manually

As you have learned, InfraWorks 360 will automatically place a culvert wherever a water area or stream crosses a design road. At times, you may need to create culverts where there is no road, stream, or water area. In these cases, you can use the Culverts tool and handpick where a culvert starts and ends.

The Culverts tool is on the Design toolbar of the Drainage Design tools, as shown in Figure 2.23. After launching the command, you simply click two points representing either end of the culvert. InfraWorks will automatically place the invert of each end of the culvert to match the ground elevation of the model. The end of the culvert with the higher elevation will automatically be designated as the upstream end, and the lower elevation will be the downstream end, regardless of which direction you draw the culvert. After you pick the second point, the Culvert asset card will open automatically. If the upstream end of the culvert is near the outlet point of a watershed, the calculated Q100 flow will automatically be applied to the culvert, and it will be sized accordingly.

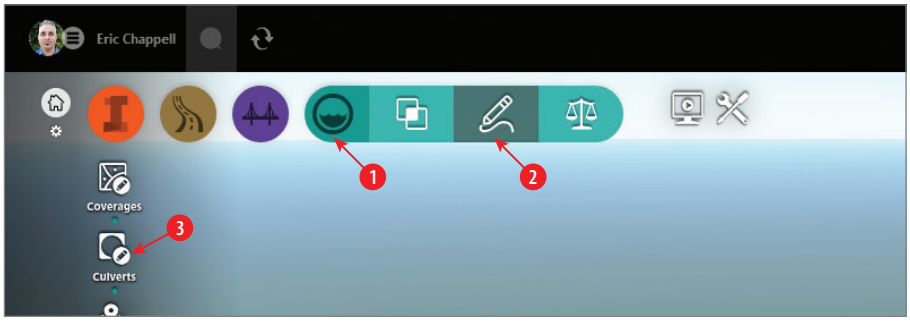


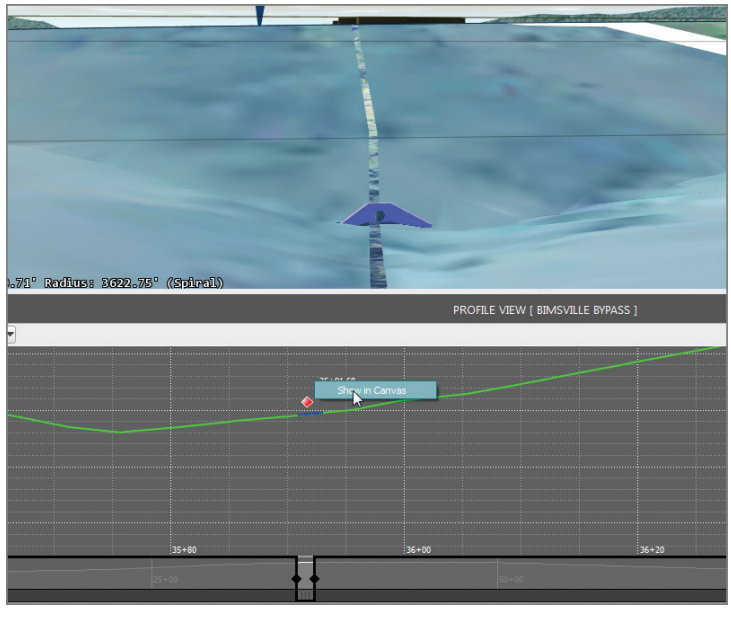
FIGURE 2.23 To launch the Culverts tool, you can click the icons in the order indicated by the numbers.

Culverts in Profile

If you view a design road in the Profile View panel and a culvert is present for the road, it will show up in the profile in the form of a blue diamond symbol. If you click the blue diamond, a label will appear next to it that reports the station and elevation where the culvert crosses the road centerline. If you right-click the diamond symbol, you can click the Show In Canvas command to zoom to the culvert in the model.

(Continues)

Culverts in Profile *(Continued)*



Exercise 2.5: Create Culverts Manually

In this exercise, you will create two new culverts that allow runoff to flow beneath the industrial park development and continue westward along its natural course.

If you are continuing from the previous exercise, you can skip to step 4. Otherwise, if you haven't already done so, go to the book's web page at `www.sybex.com/go/drainagedesignessentials2e` and download the files for Chapter 2. Using the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.
2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 02\` and select `Ch02 Bimsville Drainage.sqlite`. Click Open.

4. Select Ex_2_5 from the Proposals drop-down menu.

5. Click the Bookmarks icon on the Utility Bar; then click Culvert 2 to restore that bookmark.

You are viewing the potential location of a culvert with the upstream end at the blue ribbon marker in the top of your view and the downstream end at the blue flag marker at the bottom of your view (see Figure 2.24).

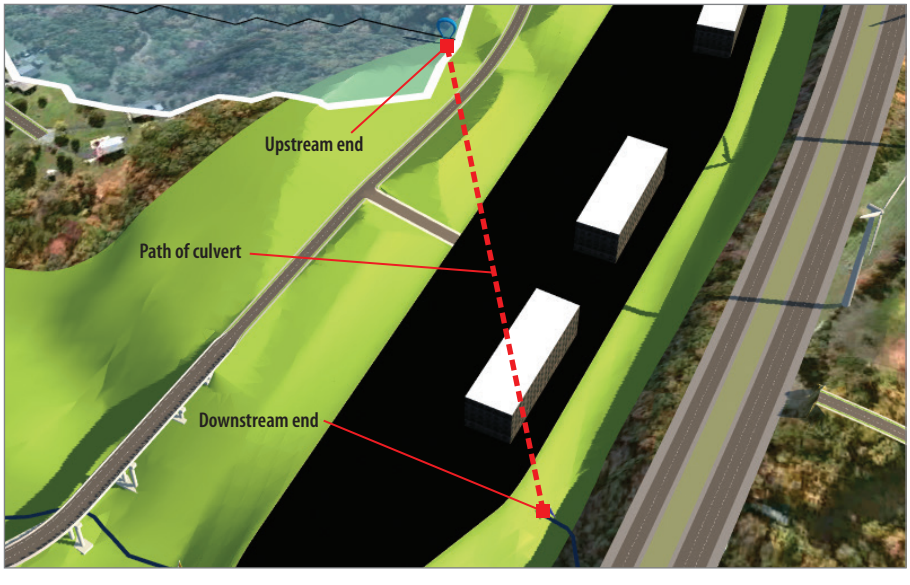


FIGURE 2.24 The potential location for a culvert

6. If the Drainage toolbar is not expanded, click the Drainage icon to expand it.

7. If the Design toolbar is not visible, click the Design icon on the Drainage toolbar.

8. Click Culverts on the Design toolbar.

9. Zoom in to the blue ribbon marker at the top of your view, and click a point near its base.

This is a very rare case where you single-click to end a command rather than double-click.

10. Zoom out until you can see the blue flag marker to the northwest (down and to the right if you haven't changed your view perspective since selecting the bookmark); then zoom into this marker and pick a point near its base.

    After a pause, a new culvert will be created.

11. Delete the flag marker at the downstream end of the culvert. The downstream end of the culvert should appear similar to Figure 2.25.

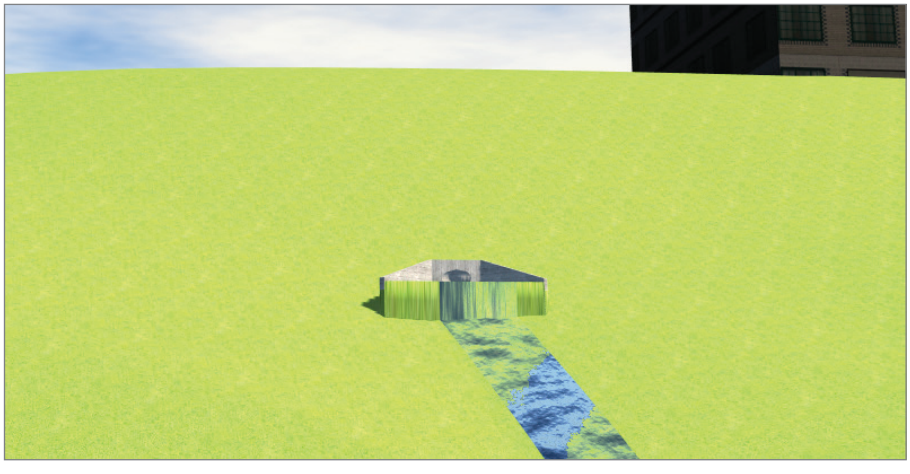


FIGURE 2.25 The downstream end of a newly created culvert

If you do not see two orange flags, your graphics settings may be too low to display both of them. Try zooming in or adjusting your settings.

12. Restore the bookmark named Culvert 3.

    You are looking at the northern end of a parking lot with an orange flag on either side of the raised area on which the parking lot rests. In the next few steps, you will create a culvert from one flag to the other.

13. Launch the Culverts tool and pick near the base of each orange flag. Delete the flags when you are finished.

    Another new culvert has been created.

    You can view the results of successfully completing this exercise by selecting the Ex_2_5_End proposal.

Editing Culverts

As with all design, the first iteration is never the last, so a good set of editing tools is always critical. When it comes to culverts, InfraWorks 360 has some tools that allow you to edit culverts graphically and through the use of the Culvert asset card. I'll discuss both of those approaches in this section.

Editing Culverts Graphically

As you have seen with other InfraWorks objects, culverts have a set of gizmos that enable specific types of graphical editing (see Figure 2.26).

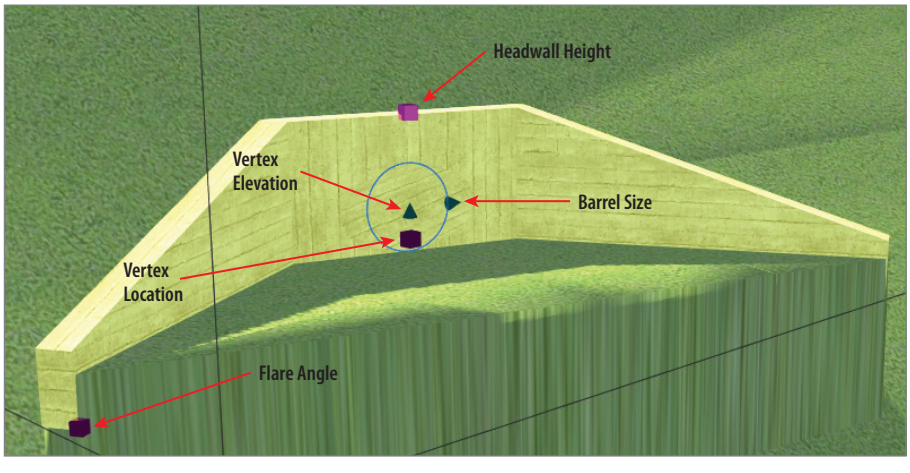


FIGURE 2.26 Culvert gizmos

Vertex Location Gizmo With this gizmo, you can move either end of the culvert to a new location. When you use this gizmo, the elevation of the culvert adjusts automatically to match the terrain. You can use the tooltip to enter specific coordinates, although this is seldom done.

Vertex Elevation Gizmo With this gizmo, you can raise and lower the elevation of either end of the culvert. If you use the vertex location gizmo to edit the location of the culvert after adjusting the elevation with this gizmo, the elevation will reset itself to match the terrain. You can use the tooltip to enter a specific elevation, but be aware that this is not the invert elevation of the barrel. It will be close but not exactly the same.

The Move Gizmo The move gizmo has four parts: three axis arrows (x, y, and z) and a square in the x-y plane. If you click and drag an arrow, you will move the entire culvert along that axis. If you click and drag the square, you will move the culvert in the x-y plane only. You can use tooltips to enter the change in a given axis, which can be especially handy in the z-axis if, for instance, you'd like to raise the culvert by a certain value.

The Barrel Size Gizmo You can click and drag this gizmo to change the barrel size of a culvert. For circular culverts, there will be only one gizmo for the diameter. For box culverts, there will be three gizmos. The one on top will change the height, the one on the side will change the width, and the one at the corner will change the height and width simultaneously. When you move any of the barrel size gizmos, they will "snap" to specific sizes to match what is commonly used in the industry.

The Headwall Height Gizmo Although this is a cube-shaped gizmo, it can move only along the z-axis and can be used to change the elevation of the top of the headwall.

The Flare Angle Gizmo This gizmo can be clicked and dragged to change the flare angle of the wingwalls. It moves in 5-degree increments and affects both wingwalls at once.

Exercise 2.6: Edit Culverts Graphically

In this exercise, you will use gizmos to edit two of the culverts in the model.

If you are continuing from the previous exercise, you can skip to step 4. Otherwise, if you haven't already done so, go to the book's web page at `www.sybex.com/go/drainagedesignessentials2e` and download the files for Chapter 2. Following the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.
2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 02\` and select `Ch02 Bimsville Drainage.sqlite`. Click Open.
4. Select Ex_2_6 from the Proposals drop-down menu.

5. Click the Bookmarks icon on the Utility Bar; then click Culvert 2 Downstream to restore that bookmark.

   You are viewing the downstream end of a culvert. The culvert opening doesn't quite match up with the end of the stream.

6. Click the culvert to display its gizmos. If the gizmos do not appear, right-click and select Edit.

7. Click the purple box gizmo at the pipe invert and drag it to the tip of the blue arc, as shown in Figure 2.27.

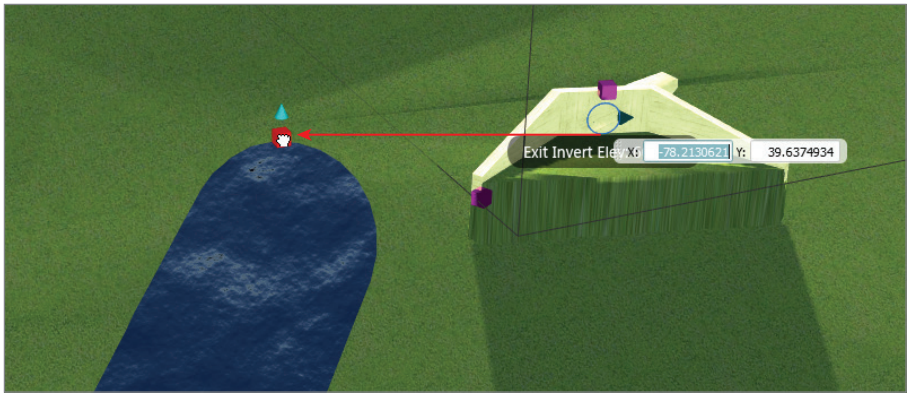


FIGURE 2.27 Relocating the end of a culvert

   After a pause, the culvert exit will line up with the end of the stream, but the elevation will be much too high.

8. If the culvert gizmos are not visible, click the culvert.

9. Click the vertex elevation gizmo, and enter **663.5 (202.23)** in the tooltip.

   After a pause, the culvert will update slightly. Using the tooltip is a handy way to provide an even value for the elevation of the culvert exit.

10. Click the barrel size gizmo and drag it to the right until the tooltip reads "Size: 36in (900mm)," as shown in Figure 2.28.

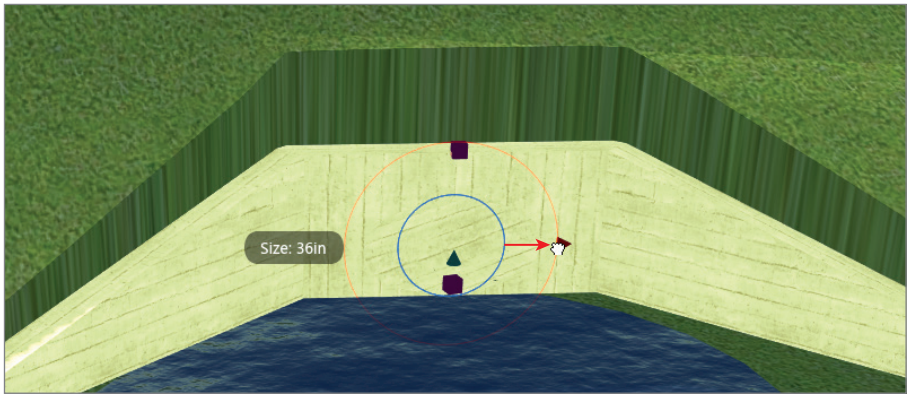


FIGURE 2.28 Resizing a culvert barrel

After a pause, the barrel size and structure will update.

11. Click the purple cube gizmo at the top of the headwall, drag it downward as far as it will go (see Figure 2.29), and then release it.

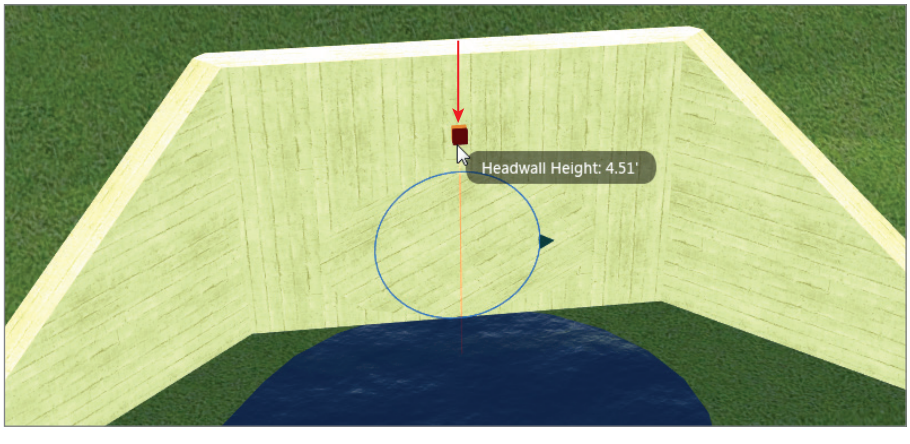


FIGURE 2.29 Changing the height of the headwall

12. Click the purple cube gizmo at the end of the left wingwall. Drag it to the left until the tooltip reads "40°."

    The wingwalls will spread slightly. The results of all your edits should appear similar to Figure 2.30.

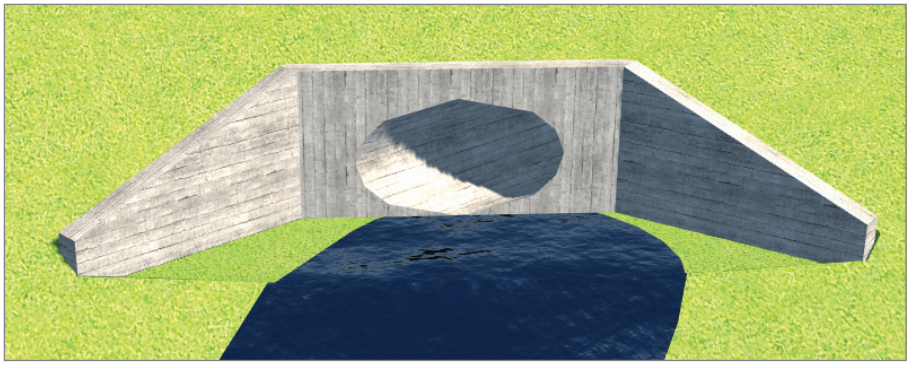


FIGURE 2.30 The results of manually editing a culvert

You can view the results of successfully completing this exercise by selecting the Ex_2_6_End proposal.

Using the Culvert Asset Card

The design of a culvert can also be edited using the Culvert asset card (see Figure 2.31). You open this asset card by simply clicking a culvert in the model. To change the values on the Culvert asset card, edit mode must be activated. Following this paragraph is a listing of the sections and options contained on the Culvert asset card. I won't discuss the Analysis section of the asset card right now; I'll save that discussion for a bit later.

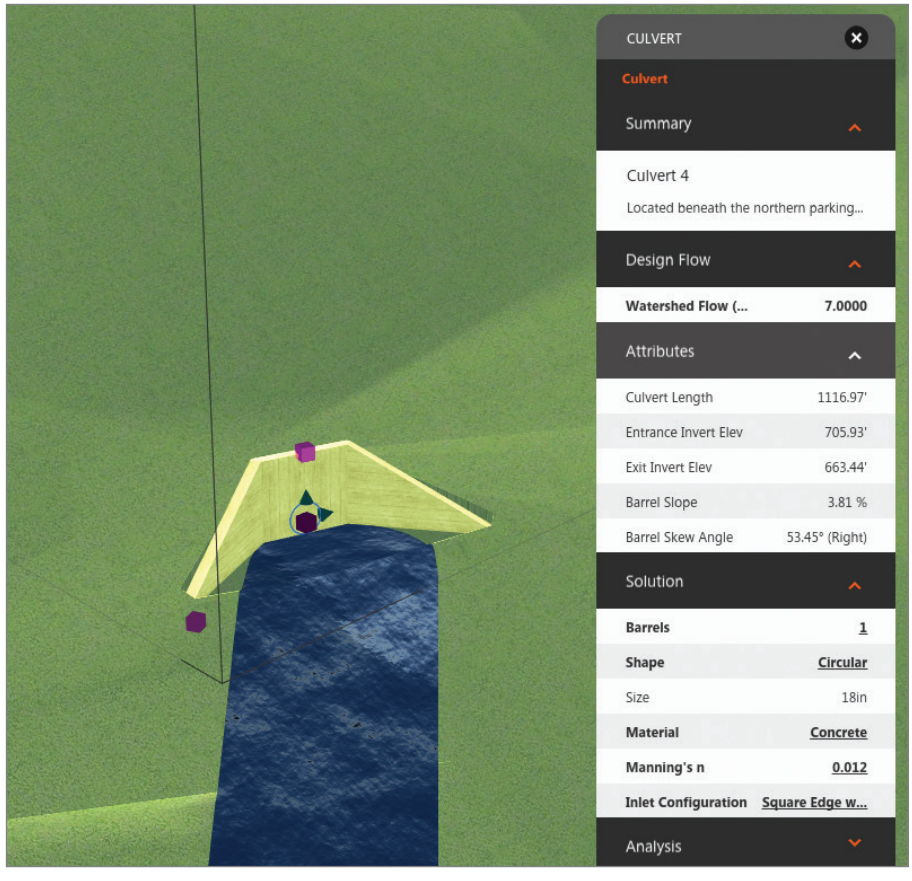


FIGURE 2.31 The Culvert asset card

Summary The Summary section contains general information: the name of the culvert and a space to provide a note.

Design Flow The Design Flow section will contain one of two possible options: Flow or Watershed Flow. If the name of the option is Flow, this indicates there is no upstream watershed associated with the culvert, and the value can be edited directly. If it is named Watershed Flow, the value is derived automatically and cannot be edited directly.

Attributes The Attributes section contains a list of geometric properties that cannot be edited.

- Culvert Length
- Entrance Invert Elevation

- Exit Invert Elevation
- Barrel Slope
- Barrel Skew Angle

Solution The Solution section is where the design of the culvert is configured. The options are as follows:

Barrels This is an integer value representing the number of barrels that make up the culvert.

Shape This option refers to the shape of the barrel(s). There are two options: Circular and Box.

Size For circular barrels, the size will be represented by one value (diameter), and for rectangular, it will display as two values (width × height). These values cannot be edited directly. The size of the barrels is changed by clicking and dragging the barrel size gizmo.

Material This refers to the material that the barrel or barrels are made of. There are two choices: Concrete and Corrugated Metal.

Manning's N The N value is a roughness coefficient that is used for sizing the barrel(s) based on flow.

Inlet Configuration This option determines the equations used when considering flow into the inlet of the culvert. For some of the choices, it also controls the configuration of the headwall and wingwalls. This is based on methodology developed by the U.S. Federal Highway Administration.

The choices for a circular culvert are as follows:

- Square Edge with Headwall
- Groove End in Headwall
- Groove End Projecting

The choices for a box culvert are as follows:

- 30deg to 75deg Wingwall Flares
- 90deg and 15deg Wingwall Flares
- 0deg Wingwall Flares

- 45deg Wingwall Flare d = 0.043D
- 18deg to 33.7deg Wingwall Flare d = 0.083D
- 90deg Headwall With 3/4″ Chamfers
- 90deg Headwall with 45deg Bevels
- 90deg Headwall with 33.7deg Bevels
- 3/4″ Chamfers; 45deg Skewed Headwall
- 3/4″ Chamfers; 30deg Skewed Headwall
- 3/4″ Chamfers; 15deg Skewed Headwall
- 45deg Bevels; 10deg-45deg Skewed Headwall

Exercise 2.7: Modify a Culvert Using the Culvert Asset Card

In this exercise, you will change the configuration of a culvert using the Culvert asset card.

If you are continuing from the previous exercise, you can skip to step 4. Otherwise, if you haven't already done so, go to the book's web page at `www.sybex.com/go/drainagedesignessentials2e` and download the files for Chapter 2. Using the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.
2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 02\` and select `Ch02 Bimsville Drainage.sqlite`. Click Open.
4. Select Ex_2_7 from the Proposals drop-down menu.

5. Click the Bookmarks icon on the Utility Bar; then click Culvert 2 Downstream to restore that bookmark.
   You are viewing the downstream end of a culvert.
6. Click the culvert to display the Culvert asset card.
7. On the Culvert asset card, click Add Note and enter **Culvert beneath parking lot number 4.**
8. Change the value for Barrels to 3.

9. Change the value for Shape to Box.
10. Change the value for Inlet Configuration to 90deg and 15deg Wingwall Flares.
11. Press Esc to clear the selection of the culvert. Zoom in and study the new configuration of the culvert.
    The culvert should look similar to Figure 2.32.

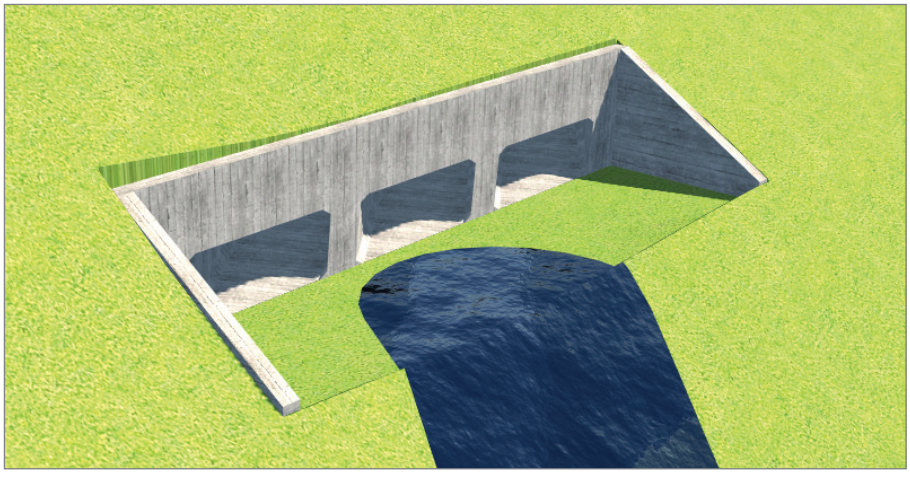


FIGURE 2.32 A newly configured culvert

You can view the results of successfully completing this exercise by selecting the Ex_2_7_End proposal.

Analyzing Culverts

In addition to placing, sizing, and modifying culverts, you can also perform an analysis of the hydraulics of a culvert. This is done using the Analysis section of the Culvert asset card. This section has the following options:

Show Analysis Results This option will toggle the graphical analysis that hovers above the culvert when you select it (see Figure 2.33). This analysis will report upstream and downstream conditions as well as flow per barrel. In addition, it will provide an interactive graphic of flow depth along the length of the culvert. As you move your cursor along the blue 3D graphic, tooltips will report the distance along the culvert versus the depth of flow.

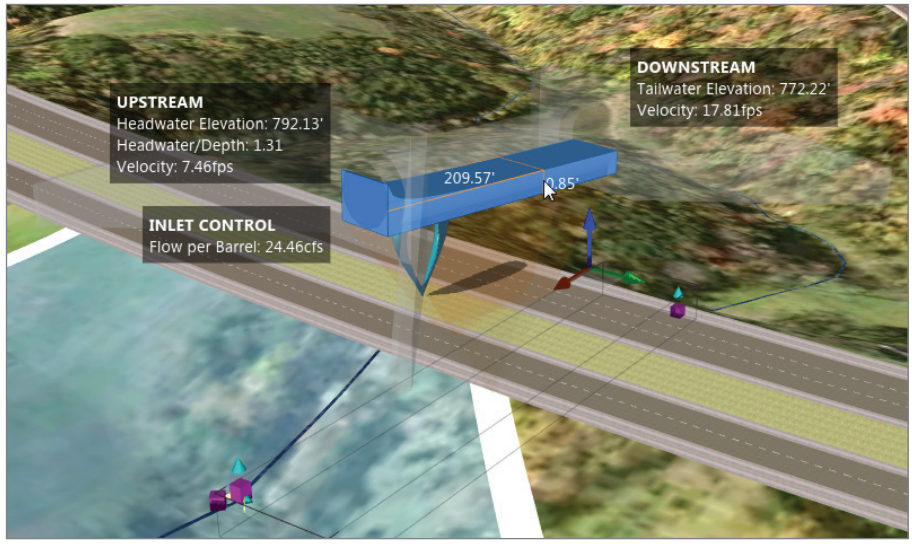


FIGURE 2.33 Graphical culvert analysis

Tailwater Condition This option controls the approach used to calculate the tailwater elevation. The choices are as follows:

- (dc+D)/2
- Crown
- Critical
- Normal
- User Defined

The User Defined option allows you to directly enter a value for Tailwater Elevation. The others provide calculated values that you cannot change directly. In the first option, dc represents critical depth, and D represents the diameter of the barrel.

Tailwater Elevation This is the calculated elevation of the water just beyond the culvert outlet. Unless Tailwater Condition is set to User Defined, this value cannot be edited but is instead calculated or taken directly from the culvert geometry. There is a built-in minimum value for this; if you enter a value that is lower, InfraWorks 360 will automatically update it to the minimum.

In addition to providing the analysis results graphically and on the Culvert asset card, Drainage Design for InfraWorks 360 enables you to export your

culvert analysis results to a file. You can do this by clicking the Generate Analysis Report icon at the bottom of the Culvert asset card (see Figure 2.34). The resulting report will open in your default browser window.

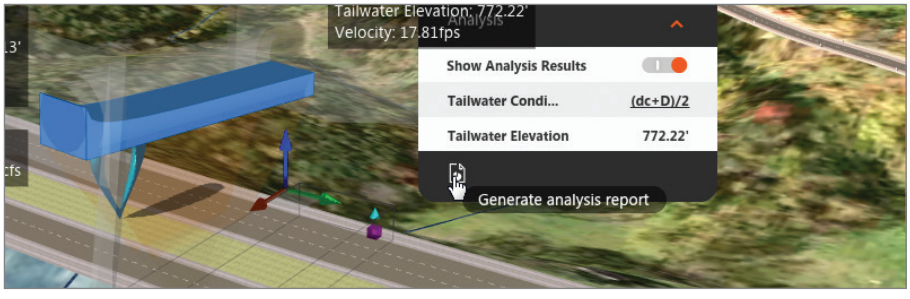


FIGURE 2.34 Exporting a culvert analysis

Exercise 2.8: Analyze a Culvert

In this exercise, you will perform a culvert analysis and export the analysis report results.

If you are continuing from the previous exercise, you can skip to step 4. Otherwise, if you haven't already done so, go to the book's web page at `www.sybex.com/go/drainagedesignessentials2e` and download the files for Chapter 2. Using the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.
2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 02\` and select `Ch02 Bimsville Drainage.sqlite`. Click Open.
4. Select Ex_2_8 from the Proposals drop-down menu.
5. Click the Bookmarks icon on the Utility Bar; then click Culvert Upstream to restore that bookmark.

   You are viewing the upstream end of a culvert that passes beneath the Bimsville Bypass.
6. Click the culvert to display the Culvert asset card.
7. Toggle on Show Analysis Results if it's not already on.

8. Restore the bookmark named Culvert Analysis.
   You should be viewing a graphical analysis of the culvert, as shown previously in Figure 2.33.

9. On the Culvert asset card, change the value for Tailwater Condition to Crown.
   The value for Tailwater Elevation updates to match the crown of the barrel outlet, which is the invert plus the diameter or 770.23 + 27/12 = 772.48′ (234.77 + 675/1000 = 235.45m).

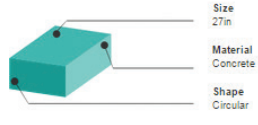
10. At the bottom of the Culvert asset card, click Generate Analysis Report.
    Your browser will open revealing the Culvert Report, as shown in Figure 2.35.

11. Close your browser window.

AUTODESK INFRAWORKS

Culvert Report

Culvert 3 | Tue May 5 02:11:10 2015 GMT



HW ELEV	HGL UP	HGL DOWN
792.13 ft	790.91 ft	771.08 ft

CULVERT

Culvert Length (ft)	326.63	Slope (%)	5.81
Invert Elev Entrance (ft)	789.18	Invert Elev Exit (ft)	770.23
Size	27in	Shape	Circular
No. Barrels	1	Manning's n	0.012
Culvert Material	Concrete	Inlet Configuration	Square Edge with Headwall

CALCULATION

Design Flow (cfs)	24.46	Flow per Barrel (cfs)	24.46
Tailwater Condition	Crown	Tailwater Elev (ft)	772.48
Velocity Up (ft/s)	7.46	Velocity Down (ft/s)	17.81
HGL Up (ft)	790.91	HGL Down (ft)	771.08
Headwater Elev (ft)	792.13	Hw/D	1.31
Flow Regime	Inlet Control		

EMBANKMENT

Top Elevation (ft)	792.13	Top Width (ft)	98.43

FIGURE 2.35 An exported culvert analysis

You can view the results of successfully completing this exercise by selecting the Ex_2_8_End proposal. You can find the export file in your Chapter 02 class data folder; it is named `Ex_2_8_End.html` (`Ex_2_8_End_Metric.html`).

Where Do the Numbers Come From?

It is important to remember that InfraWorks 360 and its vertical applications are for preliminary and conceptual design. Engineering principles and methodologies are applied, but the designs that InfraWorks 360 creates are approximate and not finalized. Drainage Design for InfraWorks 360 uses a combination of assumptions, accepted methodologies, and common practices to give you a rough design and some ideas of key analysis numbers so that you can make important decisions early. For example, if you place a culvert beneath a road, and the analysis provided by InfraWorks 360 shows that the road is being overtopped, it gives you an idea that the culvert design must be modified, the road profile should be elevated, or perhaps a bridge must be used in lieu of a culvert. It does not give you a final design that you can submit for construction or to review agencies for approval. For more information on some of the methodologies applied to culverts, research the HDS-5 methodology of the United States Federal Highway Administration.

Now You Know

Now that you have completed this chapter, you know how to create a watershed for a single point and how to create one or more watersheds along a road. You can also analyze watersheds using the Watershed asset card to calculate flows. After calculating flows, you are able to create, modify, and analyze culverts. You know how to get InfraWorks 360 to automatically create the culverts along a road, as well as how to create them manually wherever you like. You also know how to design and analyze culverts using the Culvert asset card and how to export the analysis results for further use.

Now that you have completed this chapter, you are able to begin analyzing watersheds and designing culverts for your own projects using Drainage Design for InfraWorks 360.

CHAPTER 3

Working with Drainage Networks

Now that you've learned how to deal with water passing beneath your roads, what about handling the water that flows on top of them? Drainage networks are used to collect and convey stormwater, and they are a big part of every land development design. The Autodesk® Drainage Design for InfraWorks® 360 vertical application has powerful tools that are used to create and analyze these important systems.

In this chapter, you'll learn to

- **Design drainage networks**
- **Edit drainage networks**
- **Analyze drainage networks**
- **Quantify drainage networks**

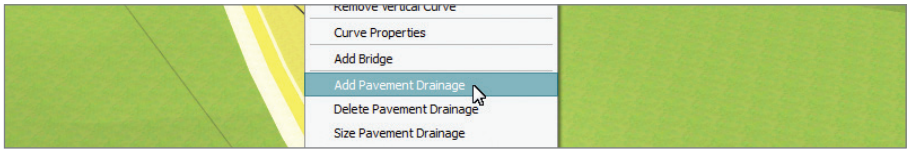
Working with Drainage Networks

A *drainage network* is a system of inlets, pipelines, manholes, and outfalls that collects and conveys drainage to a safe location where it can be discharged. Drainage Design for InfraWorks 360 provides a set of tools for creating, modifying, analyzing, and quantifying drainage networks. In this section, you'll learn about the purpose and function of drainage networks, as well as how to add them to your model and work with them to achieve your design goals.

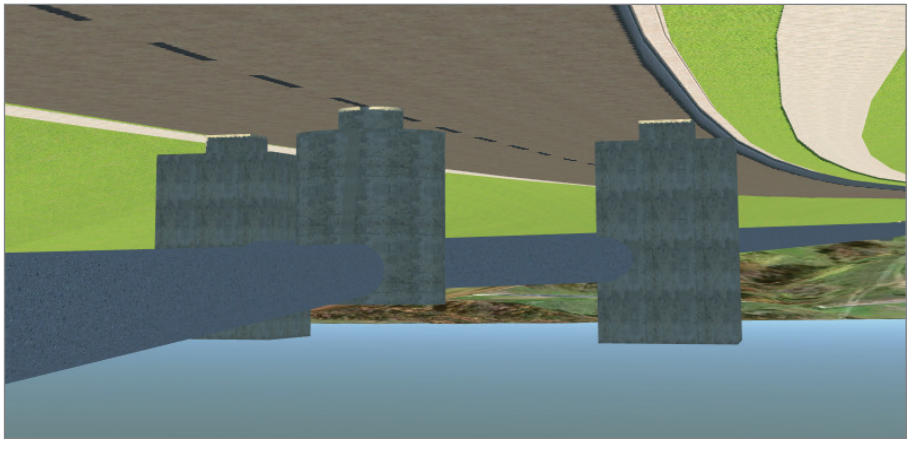
Understanding Drainage Networks

The components of a drainage network are similar to the pipelines and pipe connectors that you find in basic InfraWorks 360 software. There are a few differences that are described as follows:

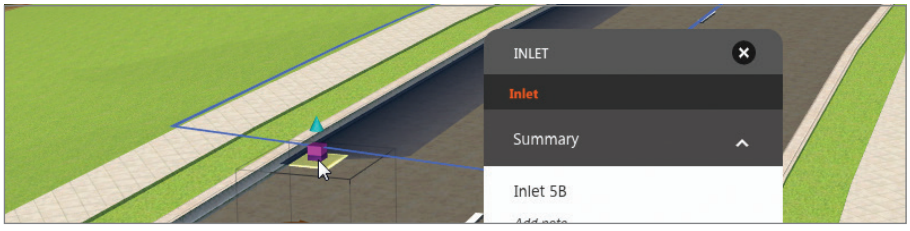
Automatic Creation You can automatically create a drainage network on a road using the Add Pavement Drainage command found in the design road right-click menu. There is no such command for the pipeline and pipe connector objects created by the basic InfraWorks tools.



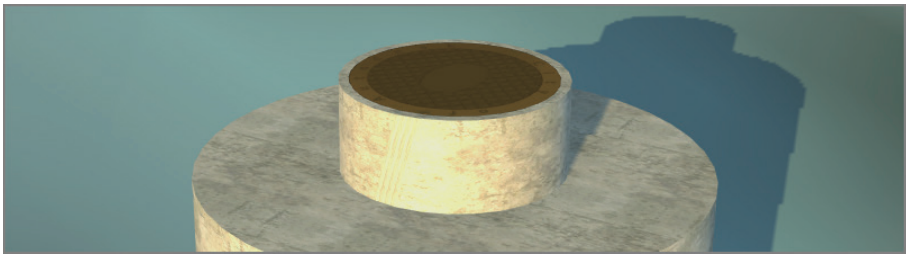
Design Rules The inlets, manholes, pipelines, and outlets you create using the drainage network tools will have depths and slopes applied automatically based on assumptions, common practices, and other design rules. For this reason, you will find that much less editing is required after you first create these objects when compared to the use of basic pipelines and pipe connectors.



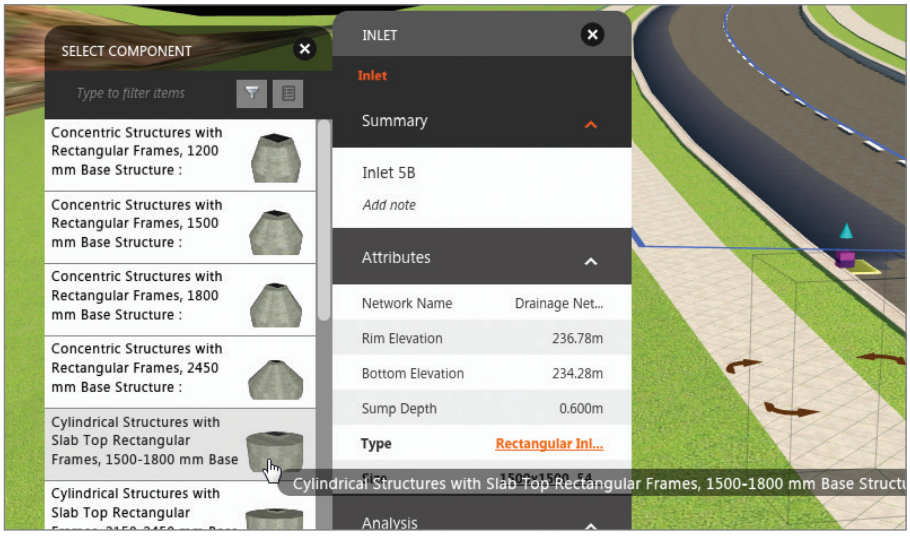
Asset Cards Drainage Design for InfraWorks 360 provides asset cards for inlet, manhole, pipeline, and outfall objects. These are not available for basic pipelines or pipe connectors.



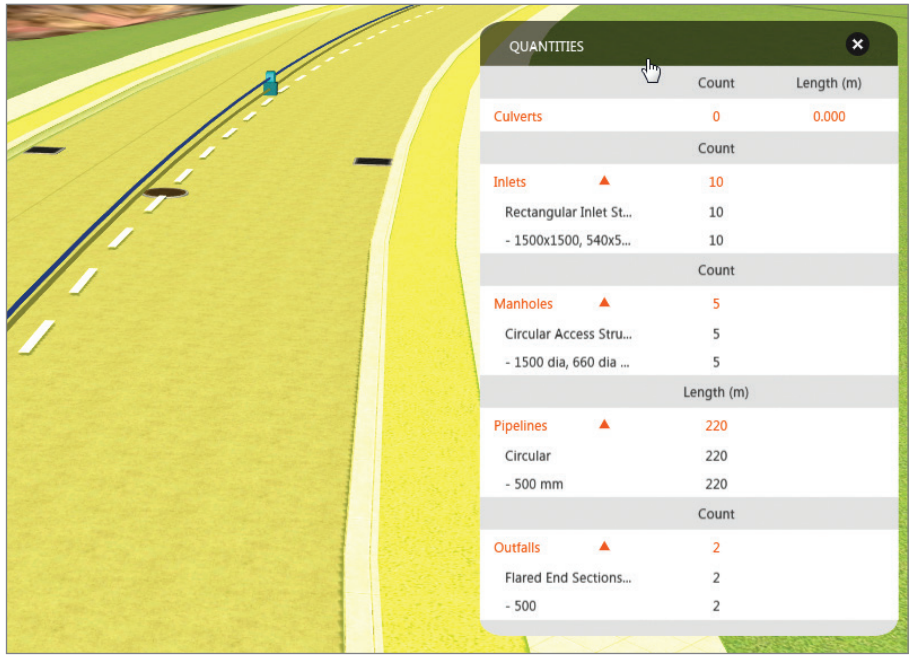
Detailed Structures The inlets and manholes that are created when you use the drainage network tools are much more detailed than those created with the basic pipeline and pipe connector tools.



Extensive Structure Library Rather than using styles to change the appearance of a pipe connector as you would with the pipelines and pipe connectors of core InfraWorks 360, inlets and manholes within drainage networks are selected from a library of components.

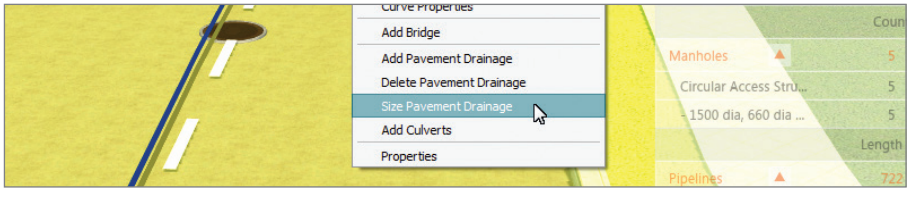


Quantities The objects in a drainage network will show up on the Quantities asset card when you launch the Quantities command found on the Analyze toolbar of the Drainage Design intelligent tools.

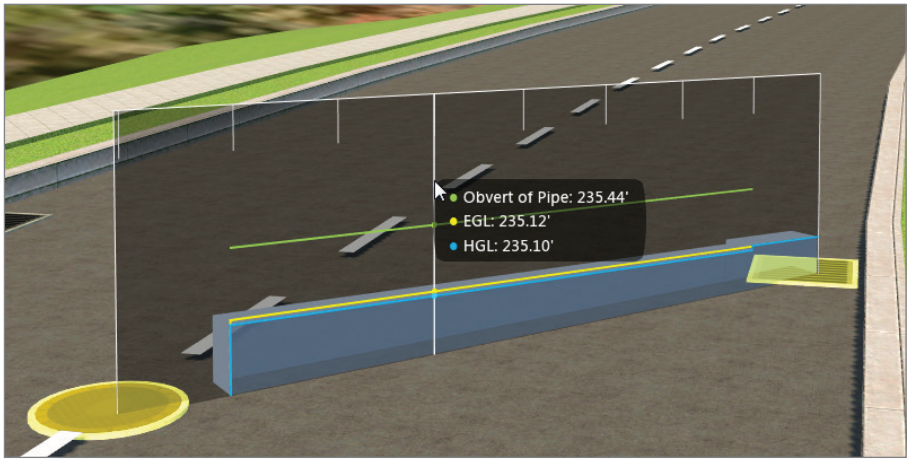


Tributary and Spread Calculations The tributary and spread calculations for inlets created by Drainage Design for InfraWorks 360 can be viewed by simply clicking one of the inlets. The software will show the tributary area, graphical representation of surface flow adjacent to the inlet, and interactive graphics that display the width and depth of flow.

Automatic Sizing You can have InfraWorks 360 calculate the sizes of drainage pipes by simply right-clicking a road containing a drainage network and selecting Size Pavement Drainage. The software will apply some assumptions along with estimated rainfall and recognized hydrologic and hydraulic methods to arrive at sizes.



Performance Inspection You can use the Inspect Performance command to determine if a pipe is suitable based on its configuration and its ability to pass predicted flows. InfraWorks 360 will provide a 3D graphic right in the model for you to visualize the results.



Creating Drainage Networks Automatically

You can create drainage networks with Drainage Design for InfraWorks 360 using two methods: automatically on a road or manually wherever you like. To create a drainage network automatically on a road, you first select the road while edit mode is on and then right-click and select Add Pavement Drainage. The Add Pavement Drainage asset card (see Figure 3.1) will open, offering you a number of options.

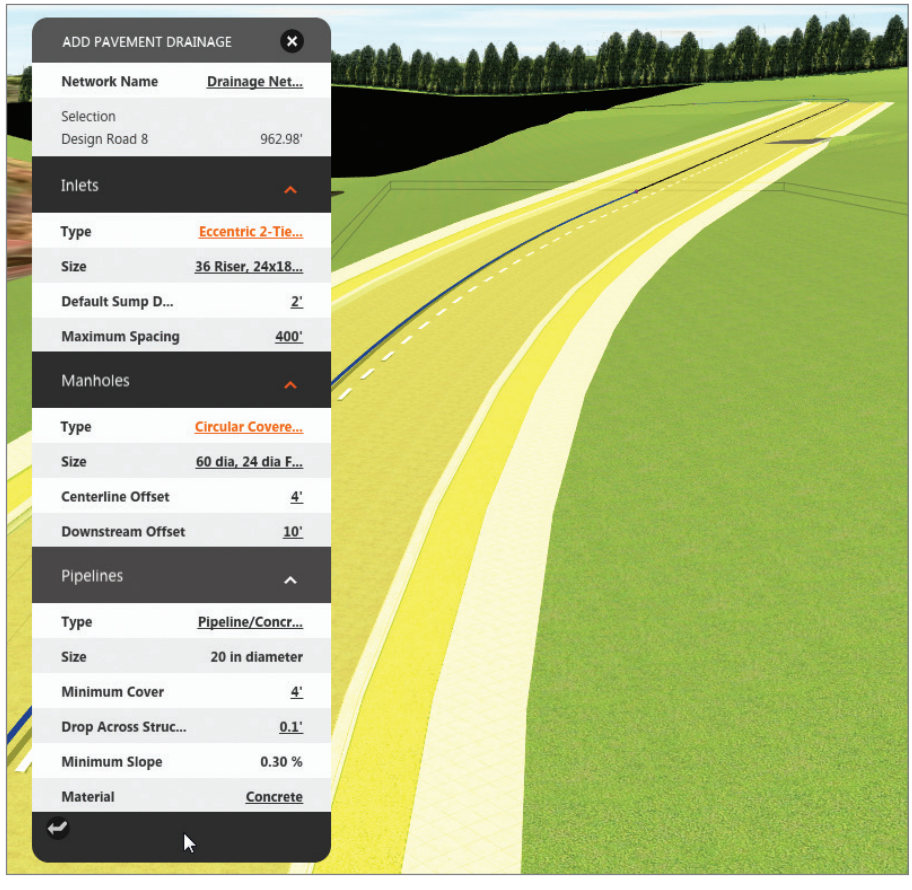


FIGURE 3.1 The Add Pavement Drainage asset card

The following describes the options available in the Add Pavement Drainage asset card.

Network Name This field can be edited so you can name your network whatever you like.

Selection This value represents the design road with which your drainage network is associated. It cannot be edited.

Inlets The values in this section are for configuring inlets.

> **Type** You can click this value to open the Select Component asset card where you can choose from an extensive list of inlets.
>
> **Size** You can choose a size for the type of inlet that you picked. The choices will vary based on what type you've selected.

Default Sump Depth This is the depth from the invert of the lowest pipe to the floor of the inlet.

Maximum Spacing The Add Pavement Drainage command will place inlets at low points and then evenly space inlets between low points. This is the minimum distance between these "in between" inlets (see Figure 3.2).

Manholes The values in this section are for configuring manholes.

Type You can click this value to open the Select Component asset card where you can choose from an extensive list of manholes.

Size You can choose a size for the type of manhole that you picked. The choices will vary based on what type you've selected.

Centerline Offset This is the distance from the centerline of the road to the locations of the manholes. If you enter a value that is the same as the lane width of your road, the manholes will be eliminated (see Figure 3.2).

Downstream Offset This is the distance between a pair of inlets and the manhole they connect to, in the downstream direction of the road (see Figure 3.2).

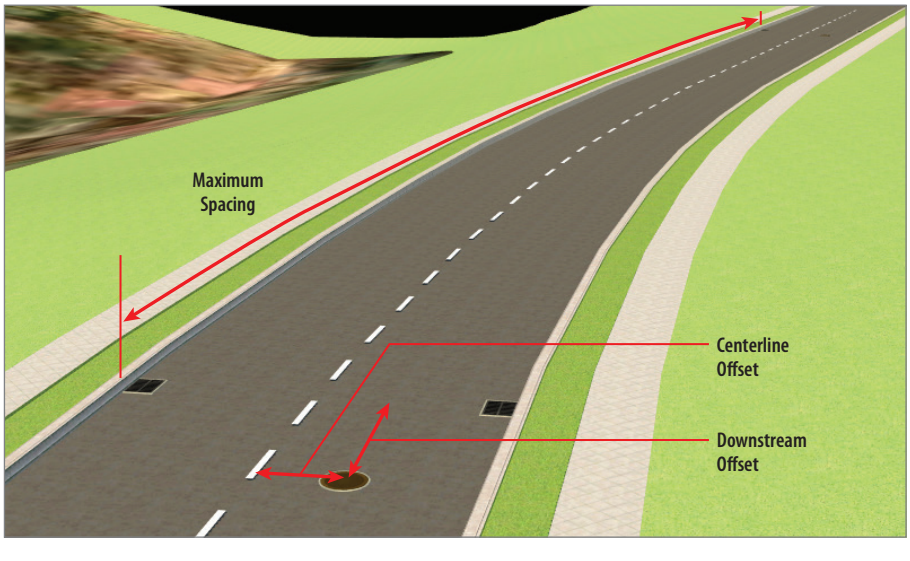


FIGURE 3.2 Dimensions that affect pavement drainage layout

Pipelines The values in this section are for configuring pipelines.

Type For this value, you choose from the available styles for pipelines. This varies from the approach for inlets and manholes, where you use the Select Component asset card to choose from a library of components.

Size The Size value is a default and cannot be edited in the Add Pavement Drainage asset card. The size of a pipe can be changed in the Properties panel or through the use of the Size Pavement Drainage command, which is covered later.

Minimum Cover This is the minimum amount of depth that is required between the surface of the terrain and the top of the pipe.

Drop Across Structure This is the elevation difference between the incoming pipe and the outgoing pipe of a given structure.

Minimum Slope This is the minimum allowable slope of a given pipe, expressed as a percentage.

Material This value is used to determine the *N* value for flow calculations and sizing.

Once you've made your choices on the Add Pavement Drainage asset card, you press Enter to begin the computation. After a few seconds, InfraWorks 360 will generate the resulting drainage network.

The network will be created by placing inlets at low points and at intervals along slopes according to built-in design rules and the values you've provided in the Add Pavement Drainage asset card. Manholes will also be created to provide connectivity between the inlets, and outfalls will be created at the low points in the system. You should know that the Add Pavement Drainage command is available only if the road style includes curbs.

To remove all of the components of a pavement drainage network, you can right-click the associated road and select Delete Pavement Drainage.

Exercise 3.1: Create a Pavement Drainage Network

In this exercise, you will use the Add Pavement Drainage command to design a drainage network for one of the industrial park roads.

If you are continuing from the previous exercise, you can skip to step 4. Otherwise, if you haven't already done so, go to the book's web page at

www.sybex.com/go/drainagedesignessentials2e and download the files for Chapter 3. Using the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.

2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 03\` and select `Ch03 Bimsville Drainage.sqlite`. Click Open.
4. If it is not already current, select Ex_3_1 from the Proposals drop-down menu.
5. Click the Bookmarks icon on the Utility Bar; then click Pavement Drainage to restore that bookmark.

   You are viewing some of the roads within the industrial park. The road you will be working on is the one in the center of your view, ending at the parking lot in the upper-left corner.
6. Click the road to select it; then right-click and select Add Pavement Drainage. If the Add Pavement Drainage command is not visible, make sure edit mode is on and that the Edit Mode property in the Road asset card is set to Geometry.

   The Add Pavement Drainage asset card will appear.
7. On the Add Pavement Drainage asset card, within the Inlets section, click the orange underlined text next to Type.

   The Select Component asset card will open.
8. On the Select Component asset card, scroll down and locate Rectangular Structures With Slab Top Rectangular Frames. Click this item.

   The Select Component asset card will close, and your selection will be applied to the Add Pavement Drainage asset card.
9. Click the value for Maximum Spacing and type **300 (92)**.
10. Within the Manholes section, click the value for Centerline Offset and enter **11.5 (3.51)**.

    This offset positions the manholes along the curb line, which will have the effect of excluding them from the design.
11. Press Enter.

    After a pause, a system of inlets, pipes, manholes, and outfalls will be created.

12. Restore the Pavement Drainage Underground bookmark.

    From an underground perspective, you can see some of the pipes and structures that have been created (see Figure 3.3).

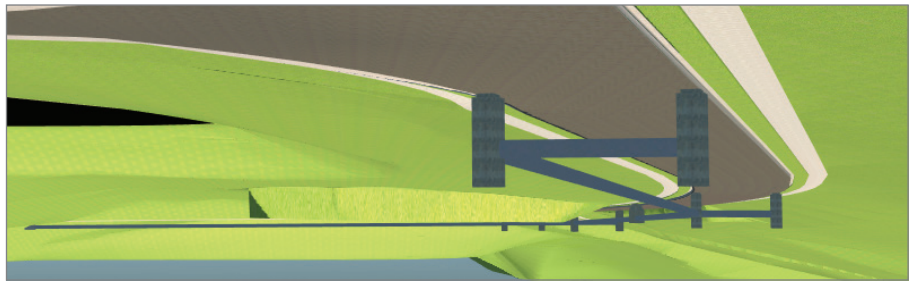


FIGURE 3.3 A newly created pavement drainage network

You can view the results of successfully completing this exercise by selecting the Ex_3_1_End proposal.

Editing Drainage Networks

The manholes, inlets, pipelines, and outfalls that make up drainage networks can be edited in the same ways as basic pipelines and pipe connectors. They have the same gizmos and exhibit the same graphical editing behavior. Asset cards are also available for these components; they allow the name and description to be edited, as well as Type and Size for inlets and manholes, and Material for pipelines. The Properties panel for drainage network components is similar to what you will find for pipelines and pipe connectors, with a few restrictions. For example, the Manual Style and Rule Style properties are not available for an inlet or manhole because their styles cannot be changed. The Properties panel is especially useful when you want to change the size of a pipe, which can be done by changing the Size X value.

Exercise 3.2: Edit a Pavement Drainage Network

In this exercise, you will use some basic editing skills to modify the pavement drainage design that was created in the previous exercise.

If you are continuing from the previous exercise, you can skip to step 4. Otherwise, if you haven't already done so, go to the book's web page at `www.sybex.com/go/drainagedesignessentials2e` and download the files for Chapter 3. Using the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.
2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 03\` and select `Ch03 Bimsville Drainage.sqlite`. Click Open.
4. Select Ex_3_2 from the Proposals drop-down menu.
5. Click the Bookmarks icon on the Utility Bar; then click Drainage Edit 1 to restore that bookmark.

   From an underground perspective, you will see a pair of inlets and some pipes that were created within the intersection of two roads. These items are not needed for your design, so you'll simply delete them in the next few steps.
6. Click one of the inlets to select it, and then press the Delete key.
7. Delete the other inlet and all of the connecting pipes using the same approach as in step 6.

   There should now be no structures or pipes beneath the intersection, and it should look like Figure 3.4.

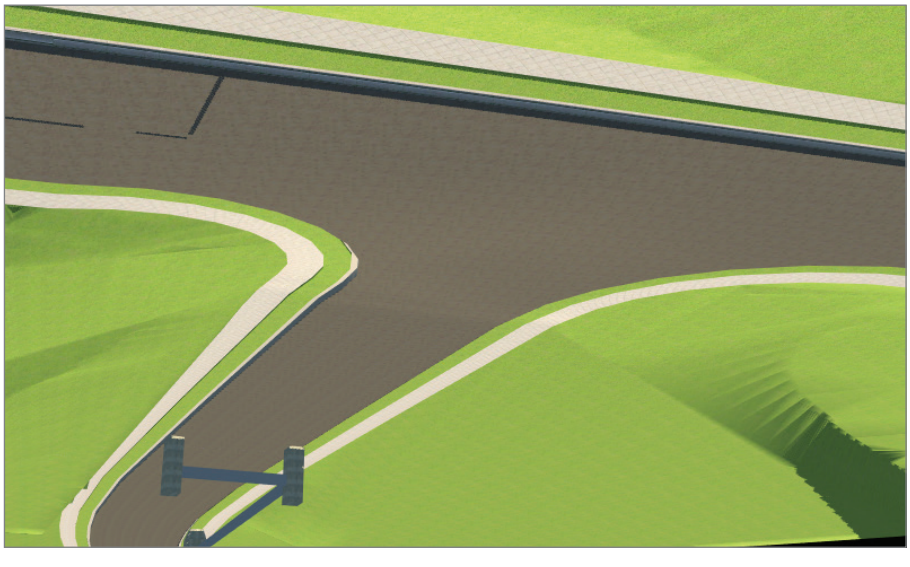


FIGURE 3.4 The structures and pipes beneath the intersection have been removed.

8. Restore the Drainage Edit 2 bookmark.

You are looking at another intersection and what appears to be a single inlet. There is actually a second inlet, but it is not visible, because it is entirely beneath the road surface. In the next few steps, you will reposition this inlet to a location just before the intersection so that it can intercept drainage before it crosses in front of the intersecting road.

9. Restore the Pavement Drainage Underground bookmark.
   You can now see the second inlet on the left side.
10. Click the inlet on the left to display its gizmos. If the gizmos do not appear, right-click and select Edit to turn on edit mode.
11. Restore the Drainage Edit 2 bookmark.
    You are now looking at the road surface again, but the gizmos for the inlet are visible.
12. Click the purple box gizmo, drag it to the beginning of the curb return, as shown in Figure 3.5, and release it.

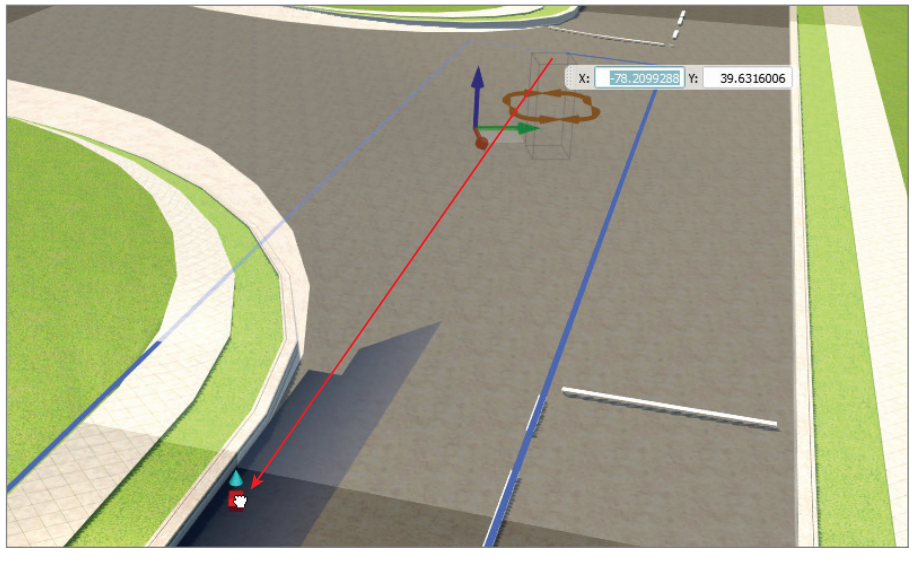


FIGURE 3.5 Changing the location of an inlet

After a pause, the position of the inlet will update and its top elevation will match the pavement surface properly, as shown in Figure 3.6.

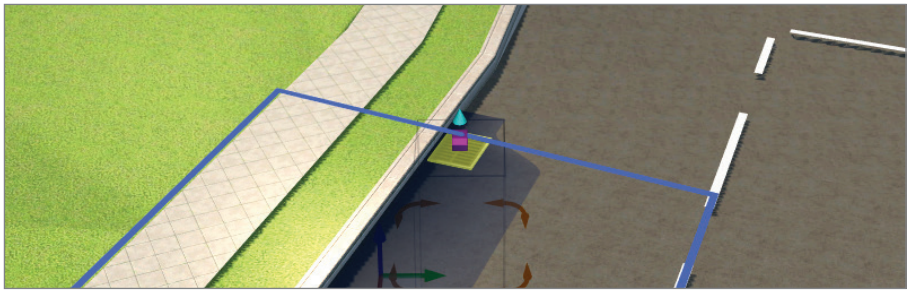


FIGURE 3.6 An inlet in its new location

13. Restore the Pavement Drainage Underground bookmark, and delete the two pipes that connect to the inlet you moved.

    With the new location of the inlet, the configuration of these pipes is not ideal. You'll replace the pipes with a better configuration in an upcoming exercise.

14. Restore the Drainage Edit 3 bookmark.

    In this view, you are zoomed into a manhole that is currently projecting above grade. In the next few steps, you'll change the type and adjust the rim elevation.

15. Click the manhole to select it. If the gizmos don't appear, right-click and select Edit.

16. Click the purple cube gizmo and use it to move the manhole to the center of the grass strip.

17. On the Manhole asset card, click the orange underlined text next to Type.

    The Select Component asset card will open.

18. On the Select Component asset card, select Eccentric 2-Tier Structures With Circular Frames, 48 Inch Base Structure.

    The Select Component asset card will close. Although you can't see it form the current perspective, the shape of the manhole has changed underground.

19. With the manhole still selected, click the cone-shaped gizmo and replace the text in the tooltip with **784.3 (228.1)**. Press Enter.

    The manhole is now flush with the surface of the ground.

    You can view the results of successfully completing this exercise by selecting the Ex_3_2_End proposal.

Creating Drainage Network Components Manually

To create drainage networks manually, you click the Drainage Network icon located on the Design toolbar of the Drainage Design intelligent tools (see Figure 3.7).

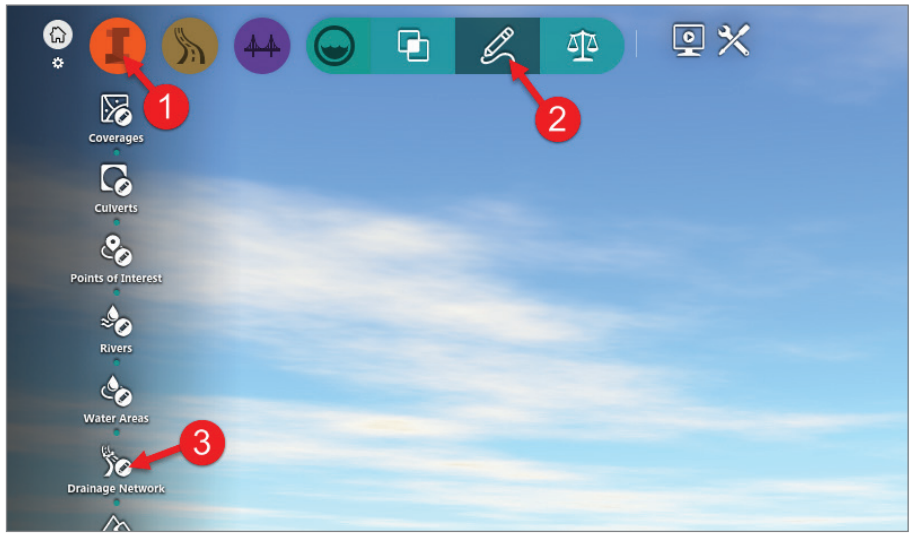


FIGURE 3.7 You can click the icons in the order shown to launch the Drainage Network command.

After launching this tool, the Sketch Drainage Network asset card will open (see Figure 3.8). Here you will be given the same options as the Add Pavement Drainage asset card, with the exception of the spacing and offset values required for laying out multiple components at once.

Once you've made your choices in the Sketch Drainage Network asset card, you can immediately begin clicking points in the model to insert inlets. As you create inlets, pipes will connect them automatically. You can double-click the last inlet location to complete the command.

FIGURE 3.8 The Sketch Drainage Network asset card

If you want other options, you can right-click while the command is active, and a right-click menu will allow you to choose which components you would like to insert as you click the model (see Figure 3.9). The choices include the following:

- Inlets And Pipelines
- Manholes And Pipelines
- Outfall And Pipeline
- Inlets Only
- Manholes Only
- Outfalls Only

If you right-click after clicking one or more points, you will get the following additional options:

- Show High And Low Points
- End Run

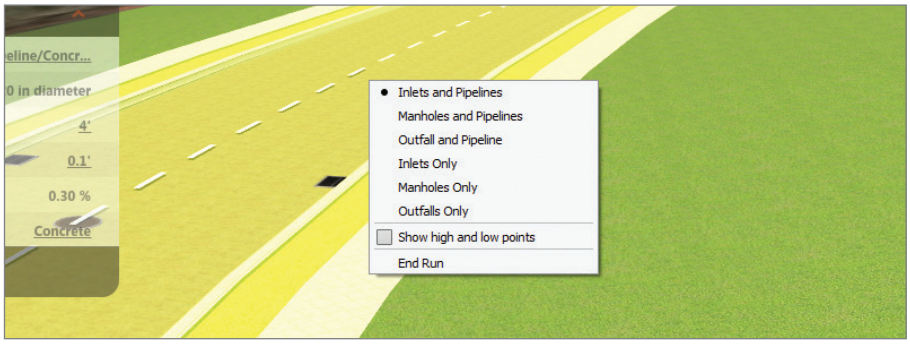


FIGURE 3.9 The right-click menu for the Drainage Network command

Show High And Low Points is handy when manually placing inlets because it will provide temporary markers and labels at high and low points for all design roads in the model (see Figure 3.10). Also, you can click inlets and manholes already in the model, and rather than creating a new structure, InfraWorks 360 will connect a pipe to the structure and extend it to the new structure that you create with the next click.

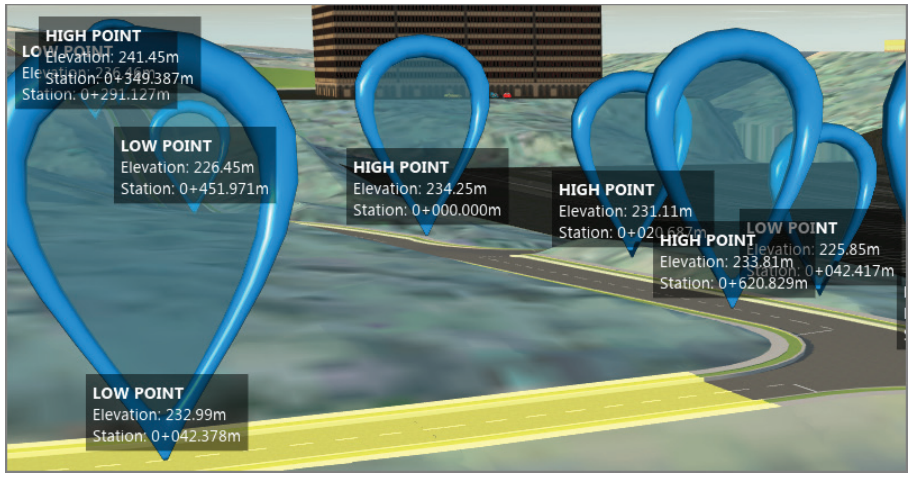


FIGURE 3.10 Markers and labels indicate high and low points in the model.

Exercise 3.3: Create Drainage Network Components Manually

In this exercise, you will use the Drainage Network command to replace the pipes and structures that you removed in the previous exercise.

If you are continuing from the previous exercise, you can skip to step 4. Otherwise, if you haven't already done so, go to the book's web page at `www.sybex.com/go/drainagedesignessentials2e` and download the files for Chapter 3. Using the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.

2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 03\` and select `Ch03 Bimsville Drainage.sqlite`. Click Open.
4. Select Ex_3_3 from the Proposals drop-down menu.
5. Click the Bookmarks icon on the Utility Bar; then click Drainage Edit 4 to restore that bookmark.

   You are looking at a plan view of an intersection at the outfall end of the system. In the next few steps, you will place two inlets, an outfall, and connecting pipes.

6. If the Drainage toolbar is not expanded, click the Drainage icon to expand it.

7. If the Design toolbar is not visible, click the Design icon on the Drainage toolbar.

8. Click Drainage Network on the Design toolbar.

   The Sketch Drainage Network asset card will open, and your cursor will change to a small crosshair.

9. Right-click and select Inlets and Pipelines from the shortcut menu.
10. Click the inlet located on the bottom (north) side of the road: then click a point at the beginning of the curb return, as shown in Figure 3.11.

FIGURE 3.11 Creating a new pipe and inlet

11. Press Enter twice to end the command. After a pause, the new pipe and inlet will be created. You may not be able to see the inlet because it may have been placed just below the pavement surface. If that is the case, navigate below ground, select the inlet, and use the elevation gizmo to change the rim elevation to 765.60 (233.35).
12. Click Drainage Network on the Design toolbar.
13. As shown in Figure 3.12, click a point across the road from the new inlet, and then click the new inlet.

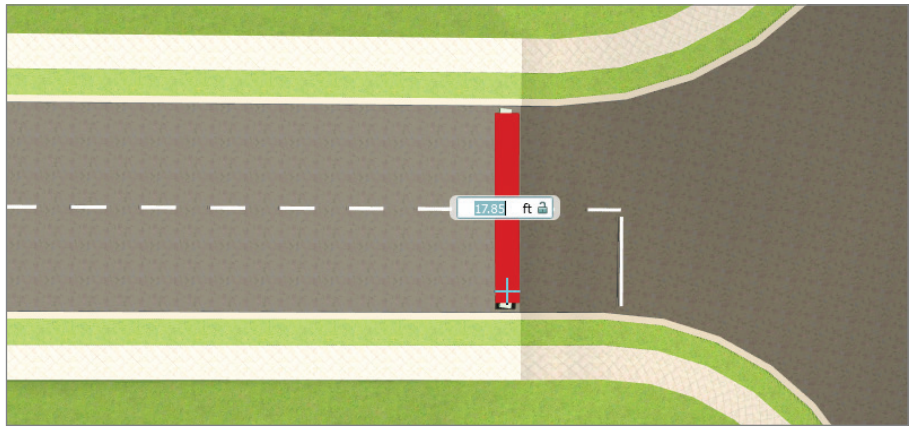


FIGURE 3.12 Creating a new inlet with a connecting pipe that crosses the road

14. Press Enter twice to end the command. After a pause, the new pipe and inlet will be created. You may not be able to see the inlet because it may have been placed just below the pavement surface. If that is

the case, navigate below ground, select the inlet, and use the elevation gizmo to change the rim elevation to 765.60 (233.35).

15. Click Drainage Network on the Design toolbar.
16. Right-click and select Outfall And Pipeline from the shortcut menu.
17. Click the new inlet located on the bottom (north) side of the road; then click a point on the embankment to the northwest (down and to the right), as shown in Figure 3.13.

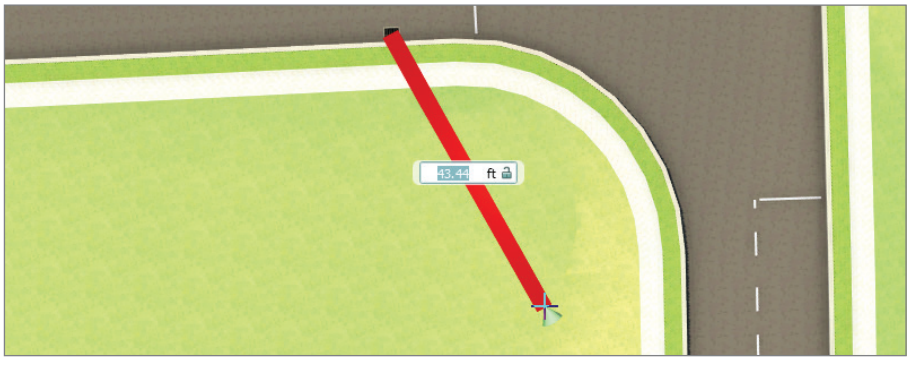


FIGURE 3.13 Creating a new pipe and outfall

A new, flared end-section outfall is visible at the second location you selected, as shown in Figure 3.14.

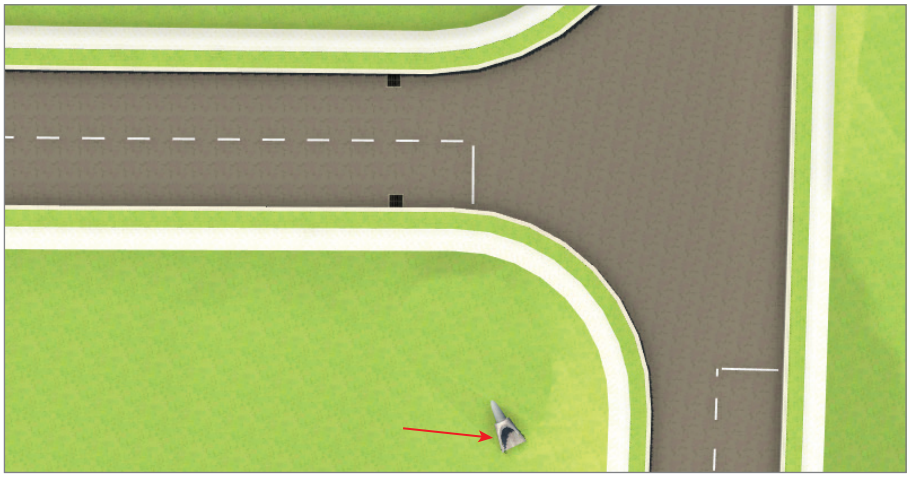


FIGURE 3.14 A newly created outfall

18. Restore the bookmark named Drainage Edit 5.
    In this view, you see two inlets and a manhole that require pipes to connect them.
19. Click Drainage Network on the Design toolbar.
20. Right-click and select Inlets And Pipelines from the shortcut menu.
21. Click the two inlets and manhole from left to right in the order shown in Figure 3.15.

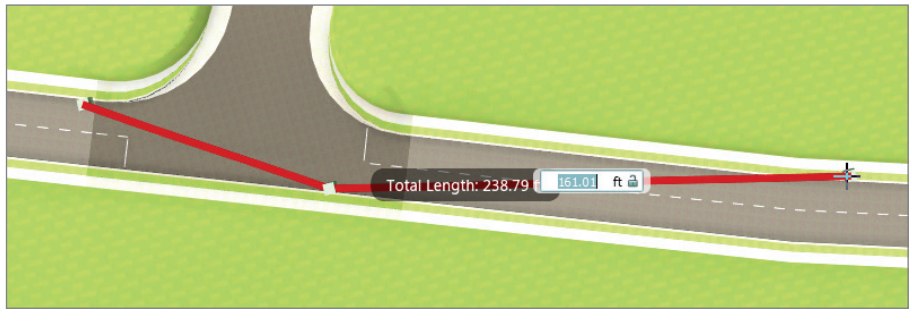


FIGURE 3.15 Selecting inlets to draw new pipes

22. Press Enter twice to end the command. Restore the bookmark named Pavement Drainage Underground.
    From this perspective, you can view the newly added pipes.
    You can view the results of successfully completing this exercise by selecting the Ex_3_3_End proposal.

Sizing, Analyzing, and Quantifying Drainage Networks

With Drainage Design for InfraWorks 360, the capabilities don't end with layout tools; there are also powerful sizing, analysis, and quantification tools that allow you to further refine your design as well as understand how it will perform and what it will cost.

Analyzing Tributary and Spread Calculations

For inlets that are placed on a road surface, you can view and analyze the performance of the inlet as it relates to spread, depth of flow, and intercepted versus bypass flow. If you are unfamiliar with these terms, refer to the sidebar entitled "Spread the Word" in Chapter 1.

To analyze an inlet, you only need to select it and turn on the Tributary And Spread toggle in the Analysis section of the Inlet asset card (see Figure 3.16). When this option is turned on, several values are reported that indicate what flows are predicted for the inlet as well as the capacity that the inlet will intercept based on its geometry and the geometry of the road.

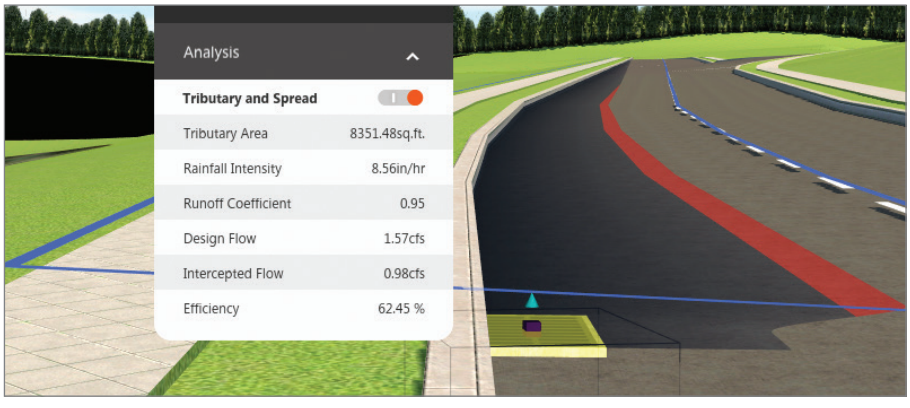


FIGURE 3.16 The Analysis section of the Inlet asset card with the Tributary And Spread option toggled on

A Tributary What?

The *tributary area* of an inlet is the area that contributes flow to that inlet. Another way to think of it is that any raindrop that falls within the tributary area will travel to the inlet you are analyzing. In InfraWorks 360, this only includes the area within the limits of the road itself. In reality, there may be areas uphill from the road that also contribute flow, and they will need to be considered separately. Determining this area is a key part of calculating how much flow should be accounted for in the design of an inlet.

There is also graphical information that helps you understand the predicted flows and performance of the inlet. A blue outline delineates the tributary area for the inlet, and a blue shaded area represents a simulation of the flow. If the allowable flow width is exceeded, there will also be a red area. You can place your cursor over the flow area and view feedback about the width and depth of the flow as well as any applicable warnings. Figure 3.17 shows an example of one inlet's graphical analysis.

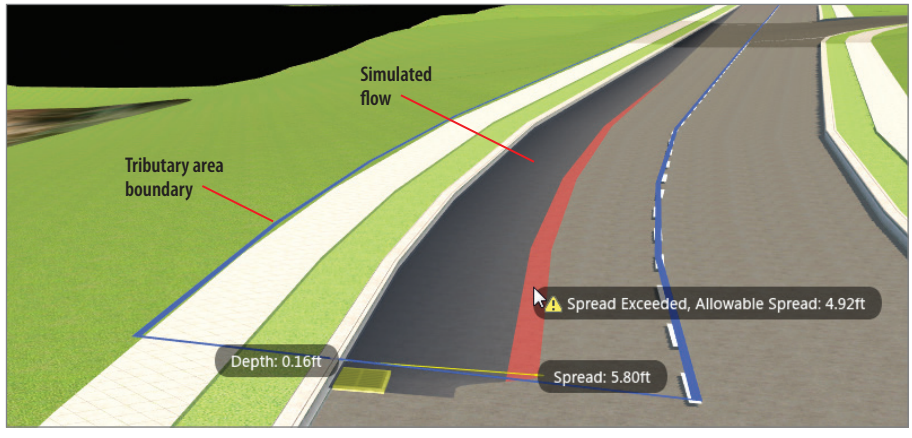


FIGURE 3.17 The analysis of an inlet represented graphically

Don't Just Go With the Flow

If you're using InfraWorks 360 "out of the box," meaning that it hasn't been customized or modified in any way, then the Rainfall Intensity values that are selected for your inlets are based on sample information that likely does not apply to the part of the world in which you are working. Rainfall Intensity is a key value that determines how much flow is expected at a given inlet. Be aware that if you're simply using this sample data, you may be under-designing or overdesigning your inlets and pipes. To correct this, you will need to work with an expert and modify the files located at `C:\ProgramData\Autodesk\InfraWorks 360\Resources\LocalLibrary\Rules\DrainageDesign\Rainfall\IDF\`.

Sizing Pavement Drainage Networks

Since flows are able to be calculated for inlets, standard hydraulic equations can be applied by InfraWorks 360 to calculate sizes for the pipes. This is done by simply right-clicking a road that has an associated drainage network and clicking Size Pavement Drainage (see Figure 3.18). There is no user input or interaction other than launching the command—the software simply changes the sizes of all the pipes.

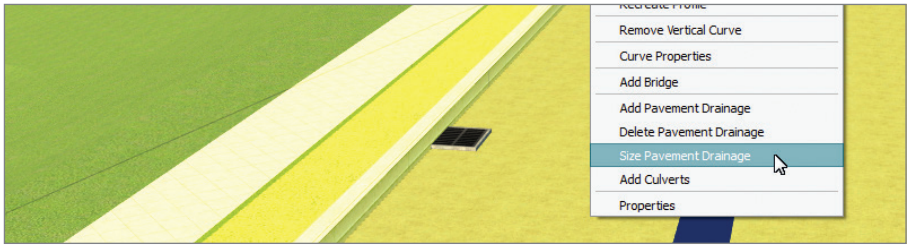


FIGURE 3.18 The Size Pavement Drainage command

Analyzing Pipe Performance

Within the analysis tools of the Drainage toolbar, there is a command named Inspect Performance (see Figure 3.19).

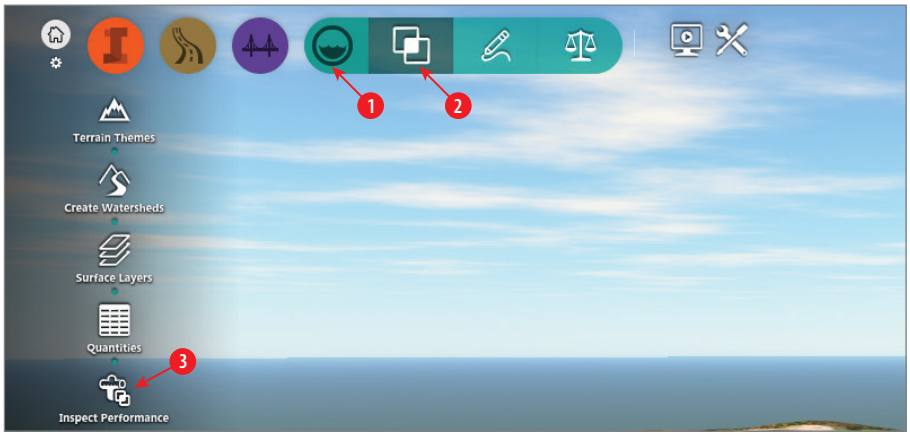


FIGURE 3.19 You can click the icons in the order shown to launch the Inspect Performance command.

When you launch this command, you are asked to select a pipe connector such as an inlet or manhole. Then any pipe connectors that are directly connected to the one you've selected will highlight in pink. You can pick one of those, and the software will automatically select the pipe that connects them, highlight it in yellow, and show a blue flow-direction arrow. When you're satisfied with your choices, you can press Enter, and a graphic will appear that

conveys information about the performance of the pipe (see Figure 3.20). This graphic includes a light-blue solid representing flow depth, a blue line representing the hydraulic grade line (HGL), a yellow line representing energy grade line (EGL) and a green line representing the obvert (top inside) of the pipe. If the HGL or EGL exceeds the obvert, the graphic will report that the pipe is surcharged—typically, a condition you want to avoid as a designer.

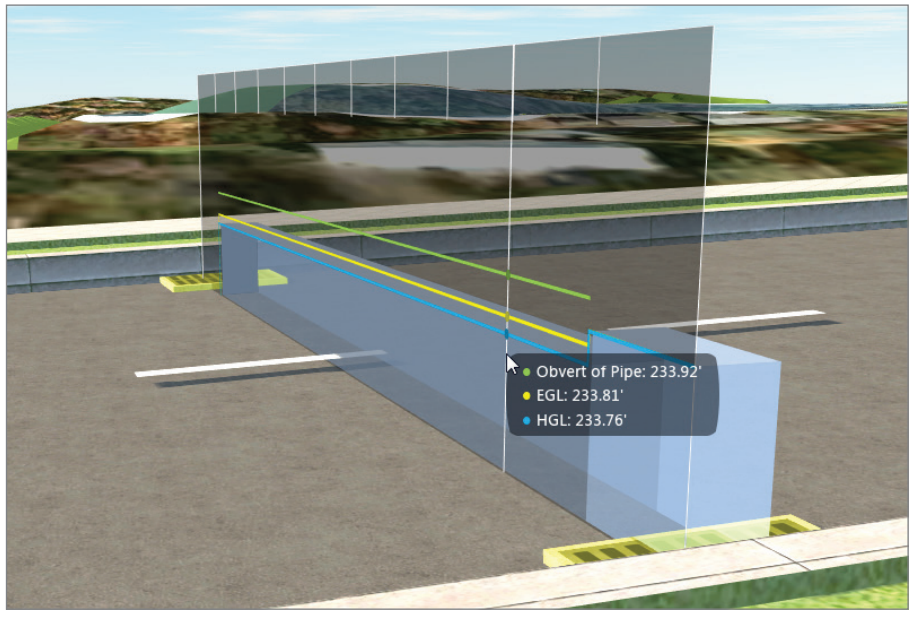


FIGURE 3.20 Graphical display of a pipe's performance using the Inspect Performance command

Calculating Drainage Network Quantities

You will find the Quantities command within the analysis tools of the Drainage toolbar (see Figure 3.21).

After launching the command, you will be prompted to select a design road. Once you've made your selection, the Quantities asset card will appear, showing you quantities for drainage network components (inlets, manholes, pipes, and outfalls) as well as culverts (see Figure 3.22).

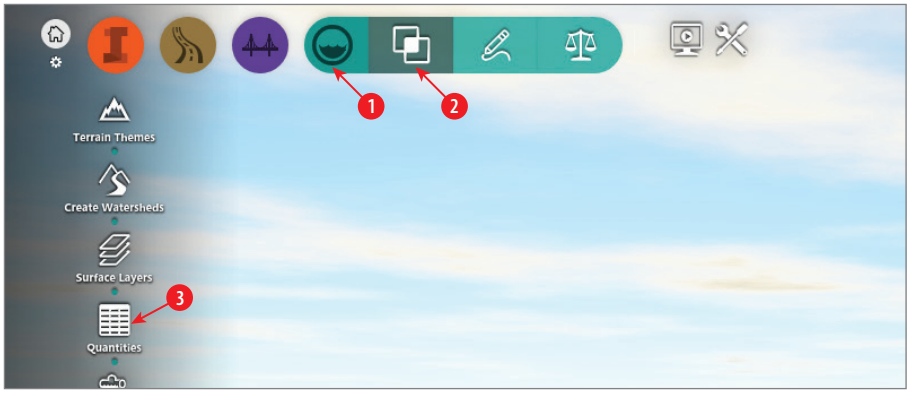


FIGURE 3.21 You can click the icons in the order shown to launch the Quantities command.

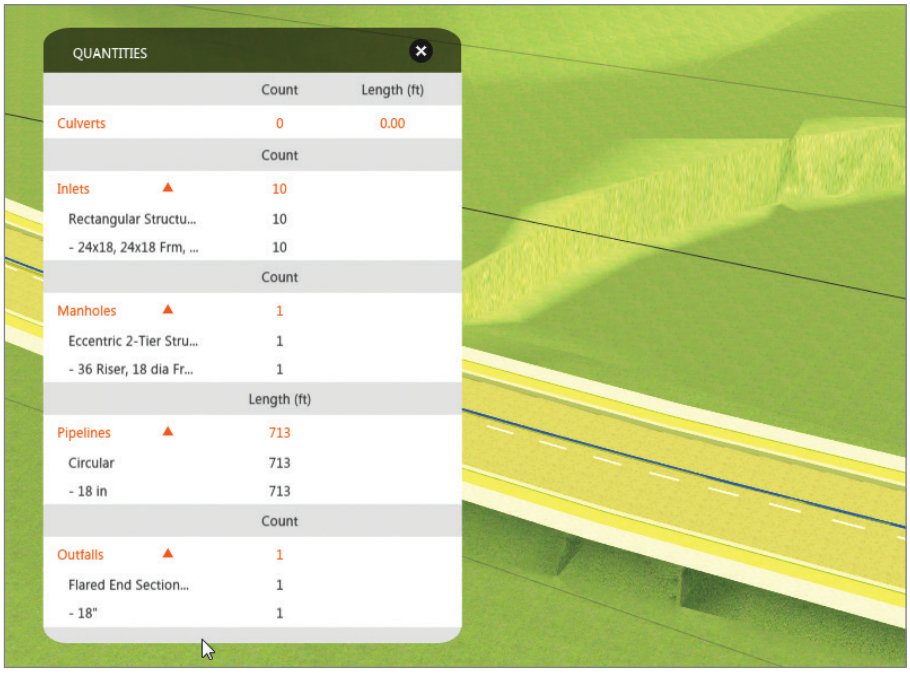


FIGURE 3.22 The Quantities asset card reports results for the drainage network components and culverts associated with a design road.

Exercise 3.4: Size, Analyze, and Quantify a Drainage Network

In this exercise, you will calculate the pipe sizes for a drainage network, inspect the performance of a pipe, and then quantify the drainage network components for a design road.

If you are continuing from the previous exercise, you can skip to step 4. Otherwise, if you haven't already done so, go to the book's web page at `www.sybex.com/go/drainagedesignessentials2e` and download the files for Chapter 3. Using the instructions in the Introduction, unzip the files to the correct location on your hard drive.

1. Launch the InfraWorks 360 software.
2. On InfraWorks 360 Home, click Open.
3. Browse to `C:\InfraWorks Drainage Essentials\Chapter 03\` and select `Ch03 Bimsville Drainage.sqlite`. Click Open.
4. Select Ex_3_4 from the Proposals drop-down menu.

5. Click the Bookmarks icon on the Utility Bar; then click Analysis to restore that bookmark.

   You are viewing two inlets placed within one of the industrial park roads.

6. If the Drainage toolbar is not expanded, click the Drainage icon to expand it.

7. If the Analyze toolbar is not visible, click the Analyze icon on the Drainage toolbar.

8. Click Inspect Performance on the Analyze toolbar.

   You will be prompted to select a pipe connector.

9. Click the inlet that is on the south side of the road (right side).

   The inlet across the road is now highlighted in pink. If you were to zoom out, you would see that a manhole and another inlet are also highlighted in pink.

10. Click the inlet directly across from the first one you selected.

A yellow stripe with a blue flow-direction arrow appears on the screen.

11. Press Enter.
    The graphical analysis appears, showing red and reporting that a surcharged pipe exists (see Figure 3.23).

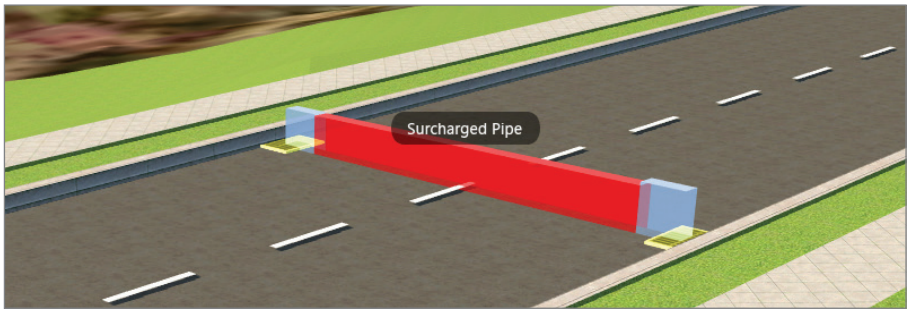


FIGURE 3.23 A pipe analysis reporting a surcharged pipe

12. Press Esc twice to end the Inspect Performance command.
13. Select the road, right-click, and select Size Pavement Drainage.
    After a pause, the pipes will be resized, but no visible change is apparent.
14. Repeat steps 8 to 11 to run the Inspect Performance command on the pipe again.
    Notice that the pipe is no longer surcharged.
15. Press Esc twice to end the Inspect Performance command.
16. Click Quantities on the Analyze toolbar.
    You will be prompted to select a design road.

17. Click the design road.
    The Quantities asset card will open and report the values for culverts, inlets, manholes, pipelines, and outfalls.
    You can view the results of successfully completing this exercise by selecting the Ex_2_12_End proposal.

Now You Know

Now that you have completed this chapter, you know how to create pavement drainage networks both automatically and manually. You also know how to modify drainage network components using graphical methods (gizmos) and numerical methods (asset cards). You understand how to analyze inlets using the Tributary and Spread calculations on the Inlet asset card along with the interactive graphics. You also know how to analyze pipes using the Inspect Performance command. Finally, you have learned how to determine the quantities of your drainage network components using the Quantities command.

With these skills, you are ready to create, modify, analyze, and quantify your own drainage networks using the powerful tools of Drainage Design for InfraWorks 360.

Index

Note to the reader: Throughout this index **boldfaced** page numbers indicate primary discussions of a topic. *Italicized* page numbers indicate illustrations.

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W

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