FLOWING WATER

"Five miles meandering with a mazy motion

Through wood and dale the sacred river ran."

—T.S. ELIOT, "*THE LOVE SONG OF J. ALFRED PRUFROCK*"

Creating a Flowing, Splashing Volume of Water

There are as many ways to approach the challenge of simulating water as there are artists interested in taking on that challenge. Given the wide variety of surface properties, mass characteristics, and viscosity changes a body of water can go through, an approach that incorporates several different techniques will probably meet with the greatest success.

In this tutorial, you will create a discrete volume of water that will flow from a tap, splash against a barrier, swirl into a funnel, and collect in a spherical jar. The water will be created using a combination of particles and solid geometry and will be controlled by space warps, deflectors, and some modifier trickery.

Project 2

Flowing Water

by Sean Bonney

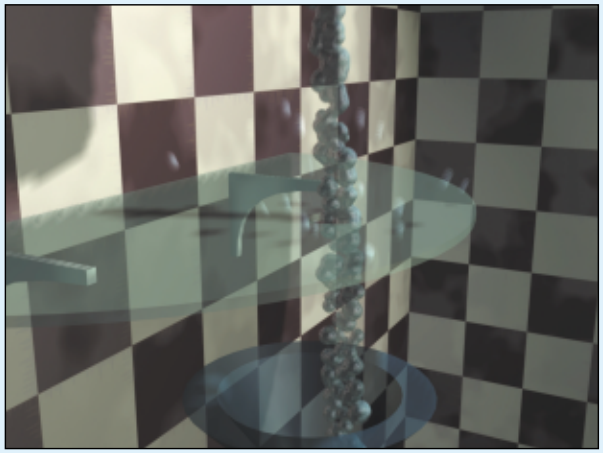
Getting Started

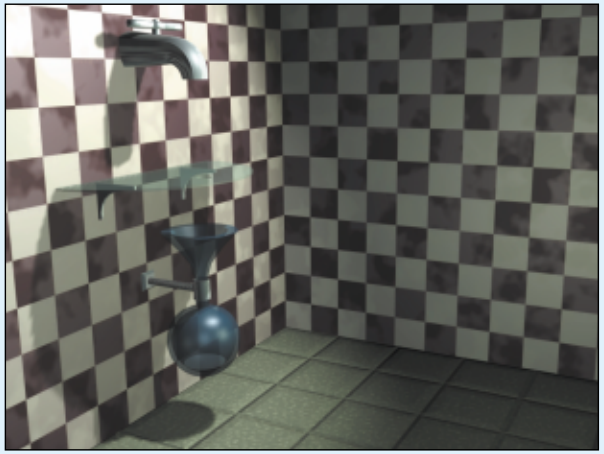
Start 3ds max 4 and open the file **FlowingWater.max** from this project's folder on the accompanying CD-ROM. To preview the final result of this tutorial, view the rendered animation **FlowingWater.avi**.

The background objects for this scene have been provided for you on the accompanying CD-ROM. If you scrub the time slider, you will note that some props have been preanimated. There are two cameras: Camera01 is a static camera that covers the entire set, and Camera02 is a moving target camera that will follow the action more closely.

Viewing the scene from either of these cameras, follow the planned course of the water:

Frame	Action
9	The main faucet handle opens, triggering a stream of water.
13–44	The stream of water issues from the faucet.
30–57	The stream passes through the hole in the glass shelf, impacting on its surface.
35	The faucet handle closes.
40–65	The water is captured by the funnel and directed into the spherical jar.
85–105	The water collects in the jar.

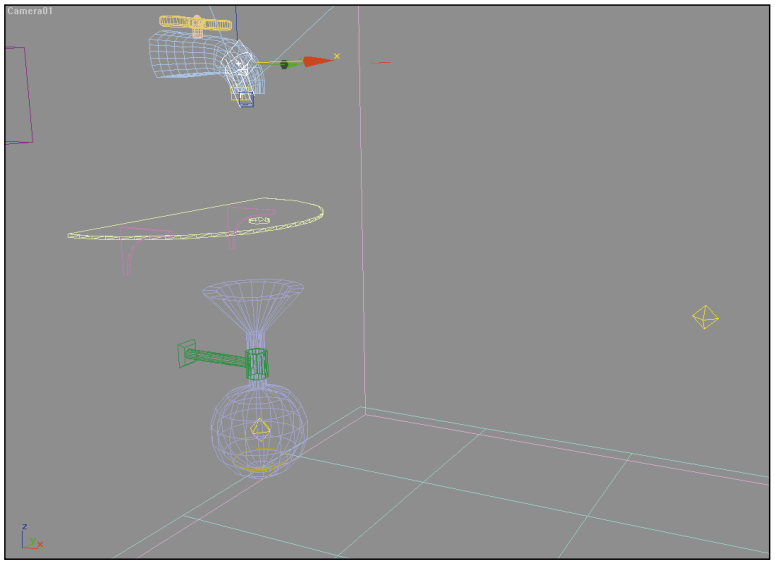




Setting Up the Initial Stream of Water

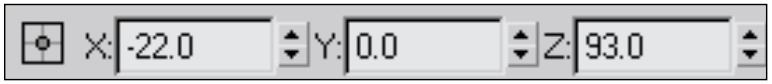
In this section, you will create a particle system to generate the stream of water and a Gravity space warp to direct the stream.

1 Go to the Top viewport and create a Super Spray particle system at X = –22, Y = 0, Z = 93. Go to the Camera01 viewport and rotate the gizmo 140 degrees on the View Y-axis.



Create a Super Spray particle system for the main stream of water.

Note: The new Transform Type-In boxes on the status bar facilitate precise positioning of scene objects.



The Transform Type-In boxes make precise positioning of scene objects very easy.

2 Name this particle system **SuperSpray_Stream** and set the following values:

Basic Parameters

Particle Formation

Off Axis Spread: **15**

Off Plane Spread: **15**

Viewport Display

Percentage of Particles: **50%**

This will cause the particle dispersion to spread over a conic area 30 degrees wide. Larger spread values would result in a wider cone.

Note: You will most likely want to reduce the displayed percentage of particles as the scene complexity increases in order to speed up screen refresh.

3 To set the speed, quantity, and size of particles to closely match the desired look of water, set the following values:

Particle Generation

Particle Quantity

Use Rate: **10**

Particle Motion

Speed: **3**

Particle Timing

Display Until: **200**

Life: **70**

Particle Size

Size: **20**

Variation: **50%**

4 Scrub the time slider to see the water particles issue from the faucet while the handle is turned to the open position.

5 Go to the Top viewport and create a Gravity space warp. Set Strength to **0.5**.

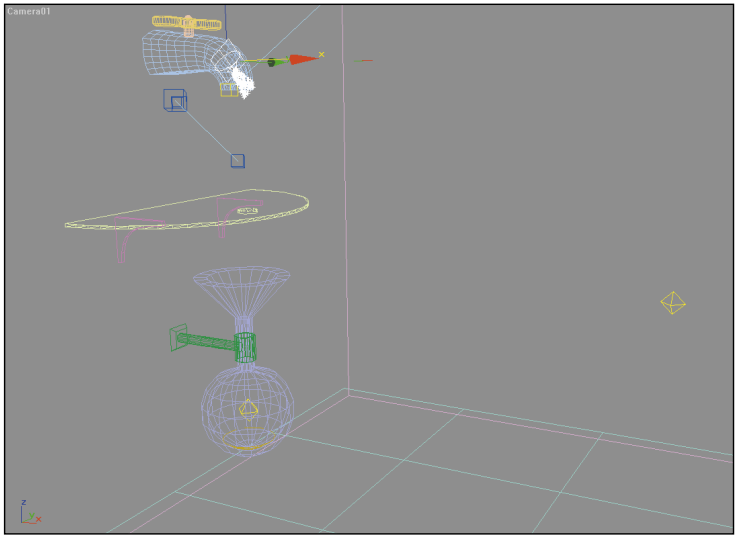
Adding the gravity effect will give the falling water a more natural look. The positioning of the Gravity space warp is not important because this space warp will not vary with distance. It will be universally applied throughout World space.

6 Use the Bind to Space Warp tool to bind the gravity effect to the particle system. Go to the Camera01 viewport.

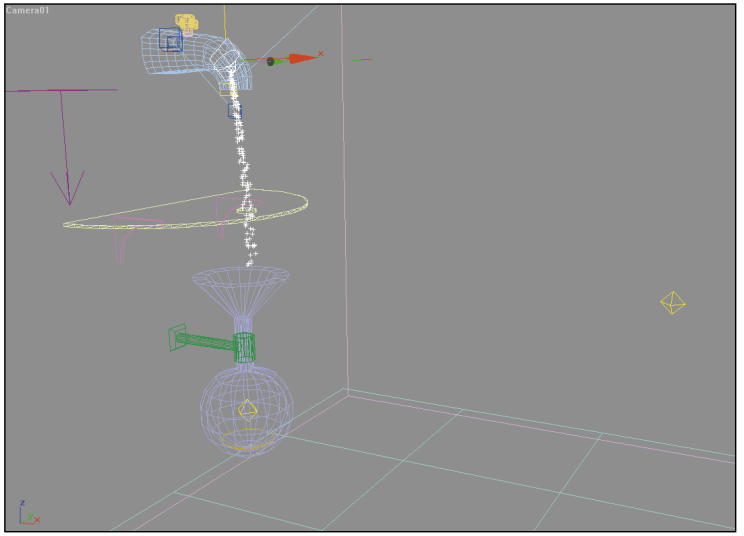
Note how the water now arcs naturally toward the floor.

Note: To change the dispersion of your generated particles, feel free to click the New button under Uniqueness to generate a new seed number.

Note: The Particle Timing settings should be given special attention because they are often a source of confusion for animators. In the event that particles seem to disappear prematurely or die out before striking a target, check these settings to ensure that the particles have been given an adequate lifespan.



A stream of particles issues from the generator within the faucet.



The Gravity space warp now sends the particles arcing toward the floor, shown at frame 37.

Controlling the Water with Deflectors

In some instances, you might want to create deflectors to keep the water from passing through the faucet head or the body of the glass shelf. Of course, the CPU overhead entailed by deflecting particles with highly detailed meshes might not always be worth the added accuracy. In this case, careful aiming of the water stream keeps it from obviously violating "solid" scene geometry, and the speed and blur of the stream should cover up any small errors.

To add a little swirl to the water as it is captured by the funnel, you will use a Motor space warp at the funnel mouth.

After the stream has passed through the glass shelf, it approaches the funnel where it will be collected and directed down into the spherical container. Although you could use the funnel/container object as a deflector to accomplish this task, it wouldn't be the most efficient choice. Instead you will use a proxy object.

1 Go to the Top viewport and create a Motor space warp at X = 0, Y = 5, Z = –645. Set the following values:

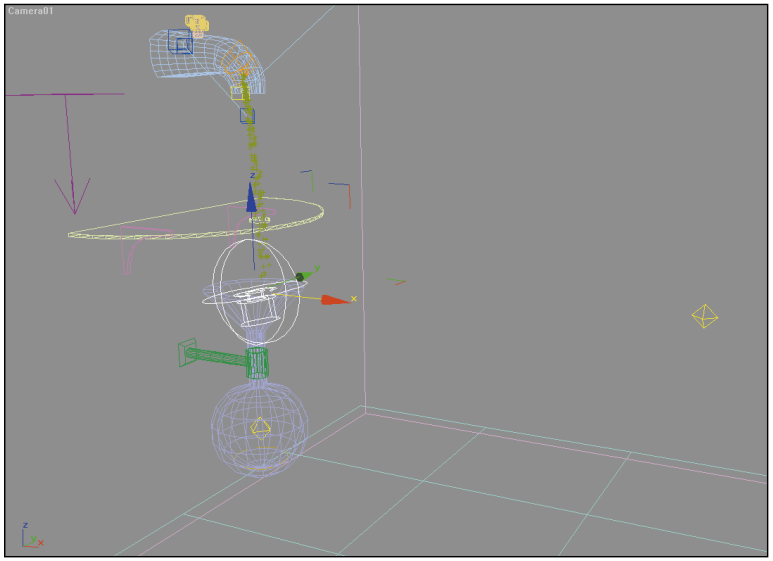
Timing
- On Time: **35**
- Off Time: **95**

Strength Control
- Basic Torque: **50**
- (Leave Type set to **N-m**)

Particle Effect Range
- Enable: **On**
- Range: **175**

The Display icon size has no bearing on the space warp's functioning, but to match the figure, set Icon Size to **100**.

2 Go to the Camera01 viewport and rotate the gizmo –20 degrees on the View Y-axis.



Create a Motor space warp to control the swirling of the particles as they enter the funnel mouth.

Note: Unlike the Gravity space warp, the placement of Motor gizmos is crucial to controlling their effect because the force is centered on the gizmo.

3 Use the Bind to Space Warp tool to bind the space warp to the particle system.

Until you have forced the water into the funnel, it will be hard to detect how the water is being subtly swirled by the Motor space warp.

4 Unhide the Funnel/Container_Proxy object.

This simple mesh object was modeled to approximate the shape of the funnel/container but with fewer polygons and, of course, only the interior faces. Notice that the upper edge of the funnel has been extended to catch stray particles. Moreover, the proxy's face normals point inward to catch particles inside the object.

5 Go to the Top viewport and create a UDynaFlect space warp. Name it **UDynaFlect_Funnel**. Set the following values:

Timing

Time Off: **200**

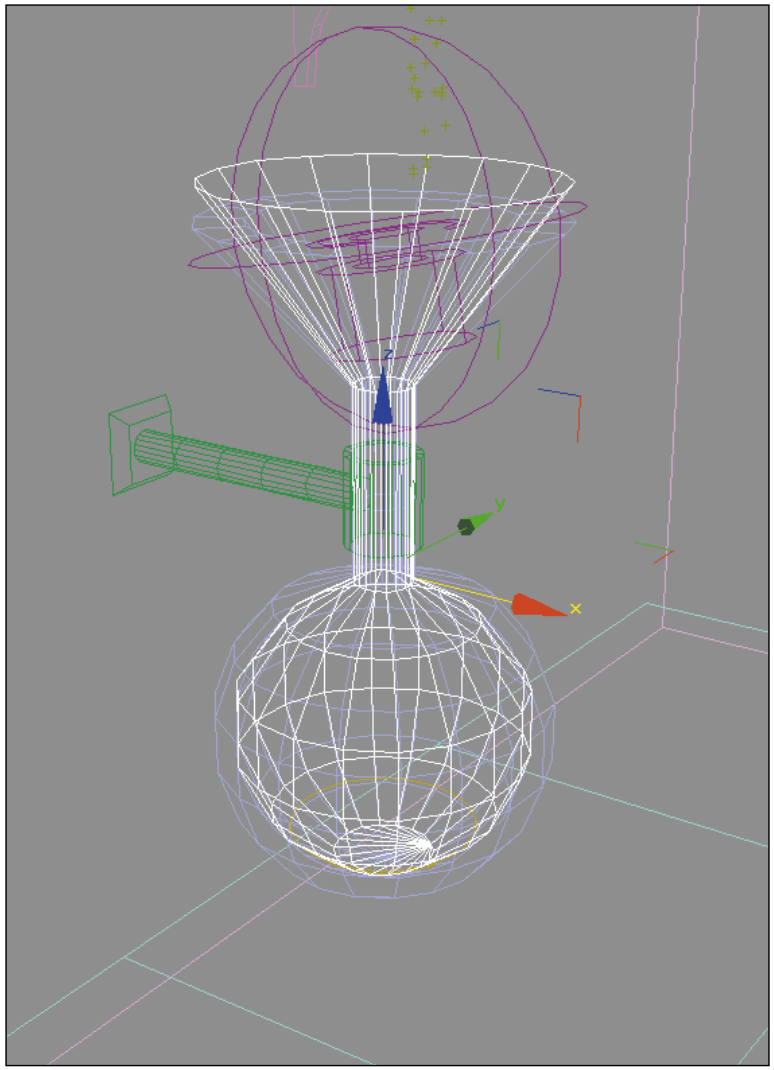
Particle Bounce

Bounce: **0.15**

Friction: **35**

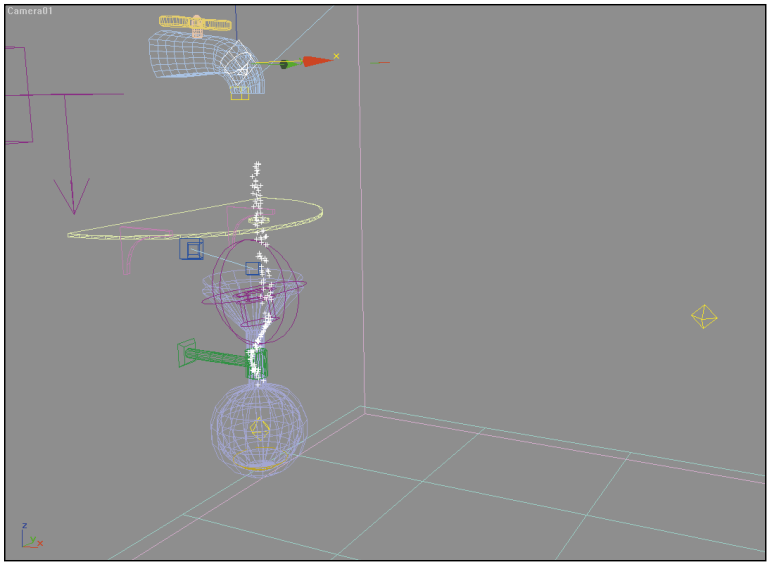
The Time Off value serves a function similar to that of the Particle Timing settings in that it determines how long the deflector solution will function in the scene. The Particle Bounce settings determine the "stickiness" of the surface. In this case, deflected particles will rebound from the surface with a low amount (15%) of reflected energy and will have approximately one-third of their momentum impeded by friction.

6 Click the Pick Object button in the Modifier panel and select the Funnel/Container_Proxy object.



This stand-in mesh will deflect particles more efficiently than the renderable version.

7 Use the Bind to Space Warp tool to bind the deflector to the particle system. Go to the Camera01 viewport and note how the water is being deflected by the funnel.



The proxy funnel mesh is now being used to deflect the particles into the funnel.

Note: If you find that some particles are escaping the funnel, try editing the proxy object to enlarge it where the hole is. Alternatively, you could try generating a new seed value for the original particle generation. If all else fails, copy the proxy, apply a Push modifier with a small negative value such as –5, and make this a second deflector to catch strays.

A Little Splash

The final effect to add is a splash of water where the stream passes through the hole in the glass shelf.

1 Go to the Top viewport and create a Super Spray particle system at X = 30, Y = 0, Z = –395. Name this particle system **SuperSpray_Splash01** and set the following values:

Basic Parameters

Particle Formation

Off Axis Spread: **90**

Off Plane Spread: **90**

Viewport Display

Percentage of Particles: **100%**

These settings will result in a wide dispersion of particles. The high display percentage will aid in visualizing how this particle system will function and shouldn't be a heavy burden on screen refresh due to the low number of total emitted particles.

2 Set the following values to control the quantity, speed, and lifespan of the spawned water droplets.

Particle Generation

Particle Quantity

Use Rate: **1**

Particle Motion

Speed: **15**

Particle Timing

Emit Start: **30**

Emit Stop: **60**

Display Until: **200**

Life: **200**

Particle Size

Size: **20**

Variation: **25%**

In this case, the Particle Timing settings are set to spawn particles during the time the original water spray is impacting with the shelf.

3 Use the Bind to Space Warp tool to bind the particle system to the Gravity space warp.

4 Go to the Top viewport and create a UDynaFlect space warp. Name it **UDynaFlect_Shelf**. Set the following values:

Timing

Time On: **0**

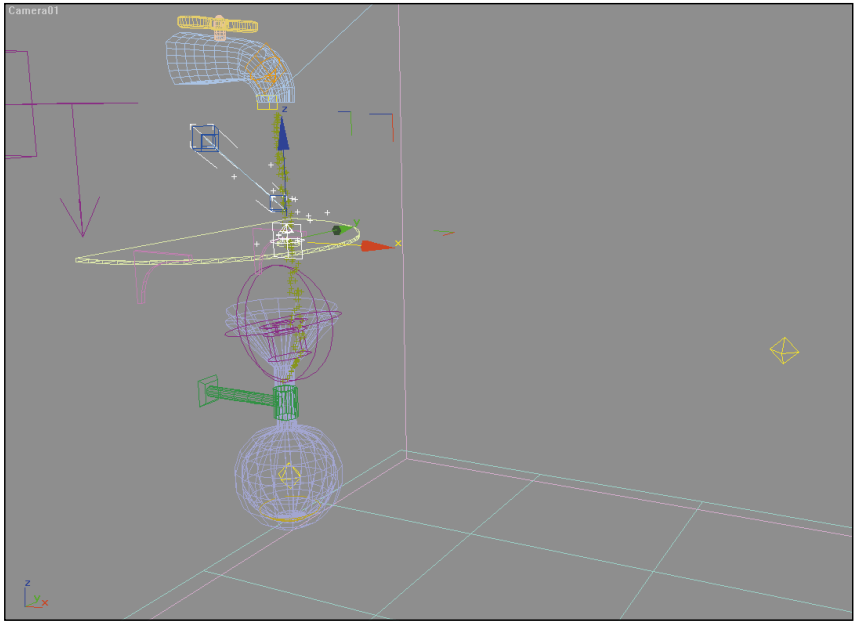
Time Off: **200**

Particle Bounce

Bounce: **0.2**

Friction: **50**

Using an Object deflector and a Planar deflector keeps the droplets from passing through the shelf and floor.



Create a Super Spray particle system to generate a small splash as the main stream goes through the hole in the shelf.

5 Click the Pick Object button and select the Shelf object.

6 Use the Bind to Space Warp tool to bind the deflector to the SuperSpray_Splash particle system. Still in the Top viewport, create a PDynaFlect space warp at X = 1000, Y = 0, Z = –1515.0. Name it **PDynaFlect_Floor**. Set the following values:

Timing

Time Off: **200**

Particle Bounce

Bounce: **0.2**

Friction: **50**

7 Set the following values to ensure that the deflector covers the entire floor area:

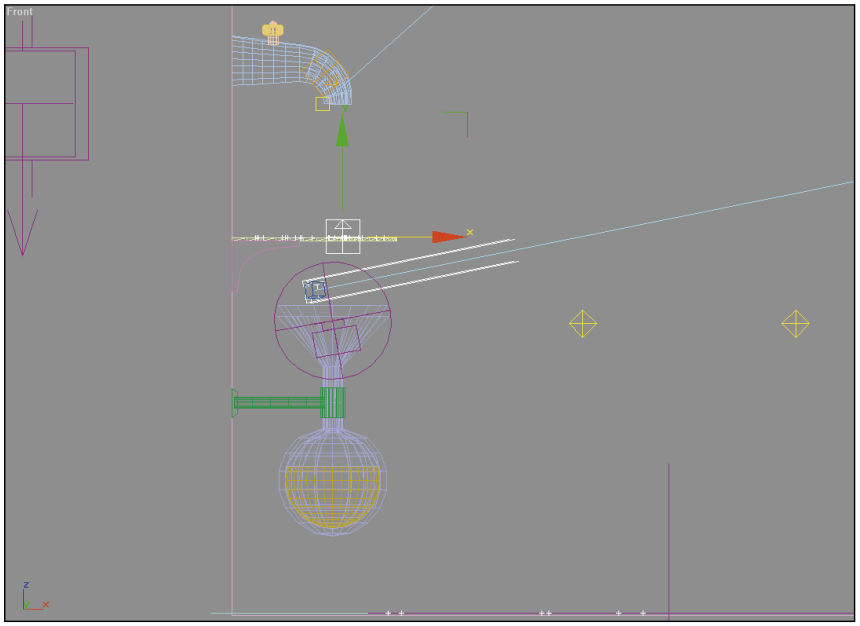
Display Icon

Width: **2800**

Height: **2800**

8 Use the Bind to Space Warp tool to bind the deflector to the SuperSpray_Splash01 particle system.

If you scrub the time slider (particularly in a Front viewport), you will notice that most of the splashed particles land on the shelf, and those that don't are stopped by the floor.



The Splash particle system is now being stopped by the shelf and the floor, shown at frame 200.

Give the Water Some Body

Up to this point, the water has been represented only by particle ticks. To successfully convey the illusion of streaming and splashing water, metablob particles will be used.

1 Select the SuperSpray_Stream system and go to the root SuperSpray object in the Modifier List. Set the Percentage of Particles displayed to **100%**.

You will be able to see all of the particles in the viewports and get a more accurate view of the overall metablob shape.

2 Go to the Camera viewport around frame 30. In the Particle Type rollout, set the following values:

Particle Types

MetaParticles: **On**

MetaParticle Parameters

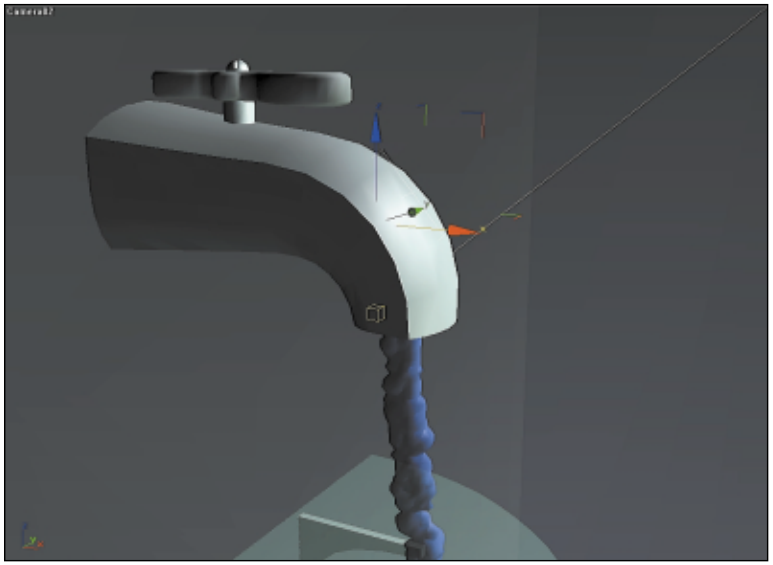
Tension: **0.1**

3 Go up to the Viewport Display area and select **Mesh**.

Notice how the particle ticks are replaced with a blobby mesh simulating cascading water. To speed up screen refresh, set Viewport Display back to **Ticks** and reduce Percentage of Particles.

4 Select the SuperSpray_Splash system and go to the root SuperSpray object in the Modifier List. Set the Particle Type to **MetaParticles**. Set Tension to **0.5**.

This will add volume to the splashed droplets.



The blobby water mesh created with MetaParticles.

Collecting the Water

If all has gone well, the main stream of water will pass through the shelf, be collected by the funnel, and be directed into the spherical jar. The particles should die out as they approach the bottom of the jar. Feel free to adjust the Life value of the particle system, if necessary, to prevent particles from bouncing around at the bottom of the jar.

The actual volume of water collecting in the jar will be created using an animated Boolean compound object.

1 Go to the Top viewport and create a Box object at X = 0, Y = 0, Z = –1225. Name this object **Box_Boolean**. Set the following values:

Length: **400**
Width: **400**
Height: **400**

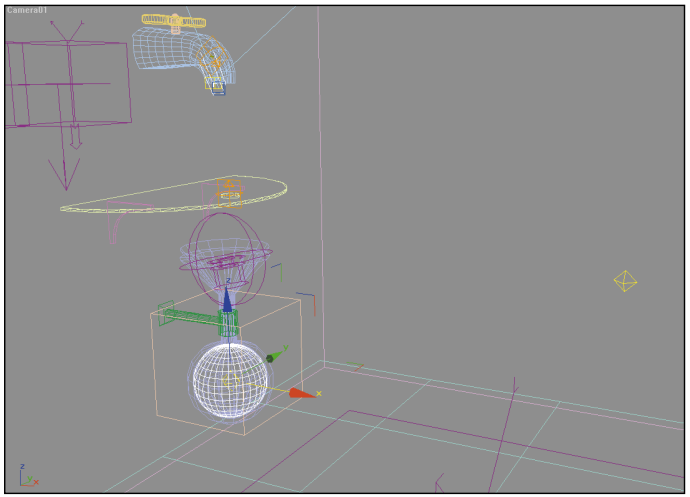
This box will be subtracted as part of a Boolean object to determine the level of the rising water.

2 Right-click on the box, go to Properties, and uncheck Renderable.

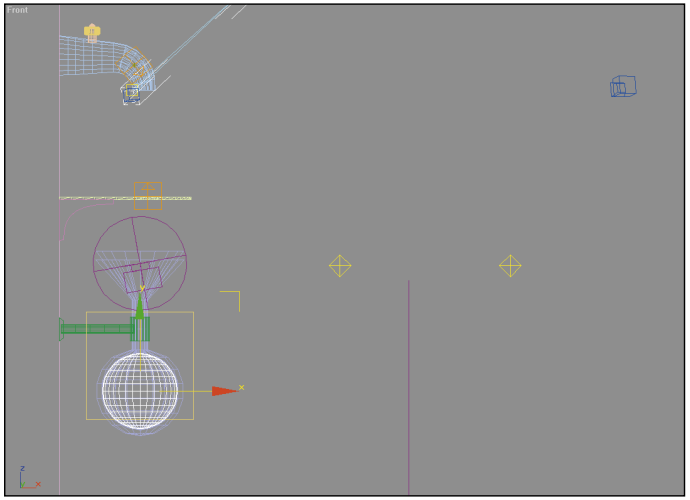
You could simply hide this object before rendering, but this extra step ensures that it will not be accidentally rendered.

3 Create a Sphere object at X = 0, Y = 0, Z = –1120. Name this object **Sphere_Water**. Set the following values:

Radius: **140**
Segments: **32**



The Box and Sphere objects used to create the animated Boolean compound object.



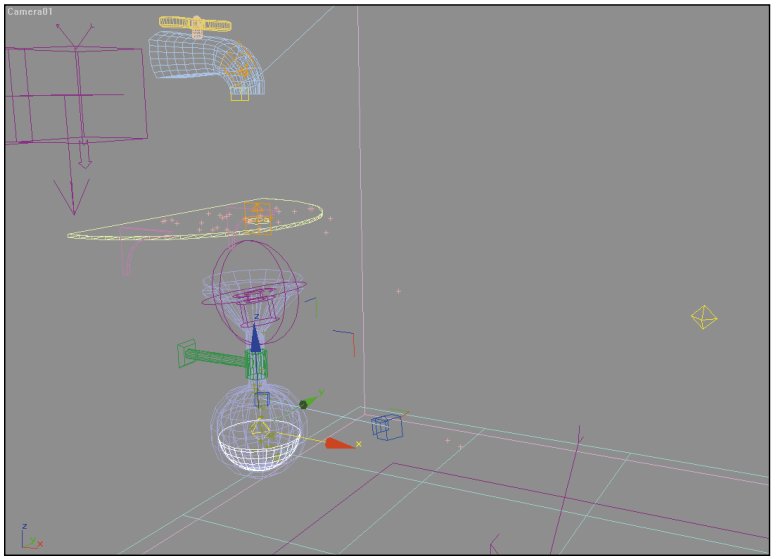
The Box_Boolean object will be animated to follow the rising water level as the stream collects.

4 Select the Box_Boolean object and turn Animate on. Go to frame 75 and set a Position key. Go to frame 105 and move the box 145 units on the View Z-axis to Z = –1080. Turn Animate off.

Note: Boolean operations can sometimes be a bit unpredictable, so it is advisable to either save your file or perform a Hold prior to creating the Boolean.

5 Select the sphere and create a Boolean compound object. Click the Pick Operand B button and select Box Boolean.

Scrub the time slider to see how the water level rises as the streaming particles enter the jar.

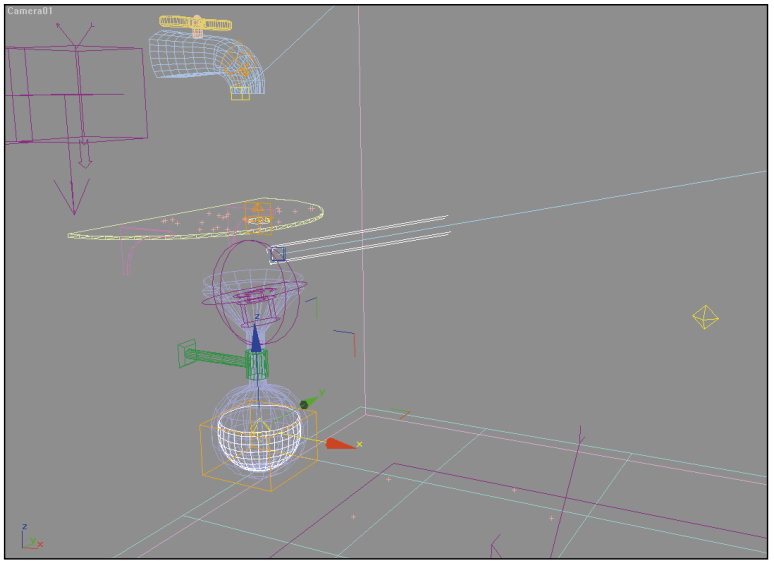


The animated Boolean object creates a rising level of water in the jar.

6 Go to frame 200 and apply a UVW modifier. Select Box as the mapping type and click the Fit button.

By fitting the Mapping gizmo when the object is at its largest, you avoid undesired UV tiling if the object should at some point exceed the gizmo's boundaries.

7 Apply an Edit Mesh modifier, go to Face, Sub-Object mode, and select all faces. Go to the Surface Properties rollout and set Material ID to **1**.



Apply a UVW modifier fit to the largest size the Boolean will attain.

The "Look" of Water

Arguably, the most important aspect of creating convincing water is the material. Given how quickly and chaotically water can move, slightly unorthodox movement or volume can be overlooked, but the most perfectly flowing body of water will not read as water without the appropriate look.

1 Go to the Camera02 viewport at frame 35.

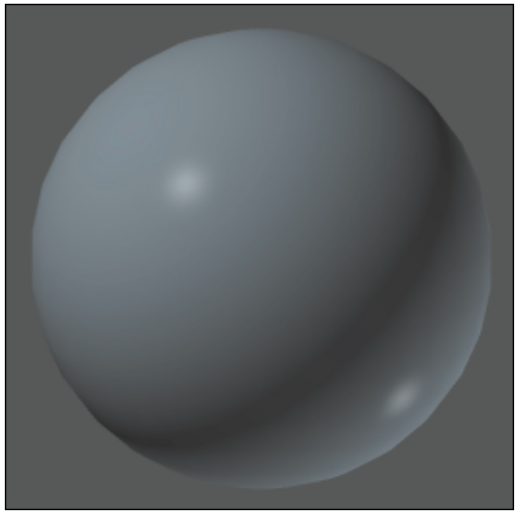
If you render a still, you will see that the default material looks more like gooey plastic than water.

Even with a nice shape, the water does not look convincing without an appropriate material.

2 Open the Material Editor and select an unused material. Name this material **Water**. Set the following values:

Diffuse Color: **R 110, G 130, B 140**
Opacity: **75**
Specular Highlights
    Specular Level: **20**
    Glossiness: **60**

This shiny, subtly transparent material will be expanded with maps to look more like water.



Create a shiny blue-green material as the basis for the water material.

3 Under Extended Parameters, set the following values:

Advanced Transparency

Falloff: **Out**

Index of Refraction: **1.3**

Reflection Dimming

Apply: **On**

Dim Level: **0.25**

The Advanced Transparency values determine that the material will become more transparent toward the outside of the object. Reflection Dimming serves to diminish the impact of reflection maps in shadowed areas of the object.

4 Go to the Diffuse Color channel and apply a Noise material. Under Noise Parameters, set the following values:

Noise Type: **Fractal**

Size: **5**

Noise Threshold

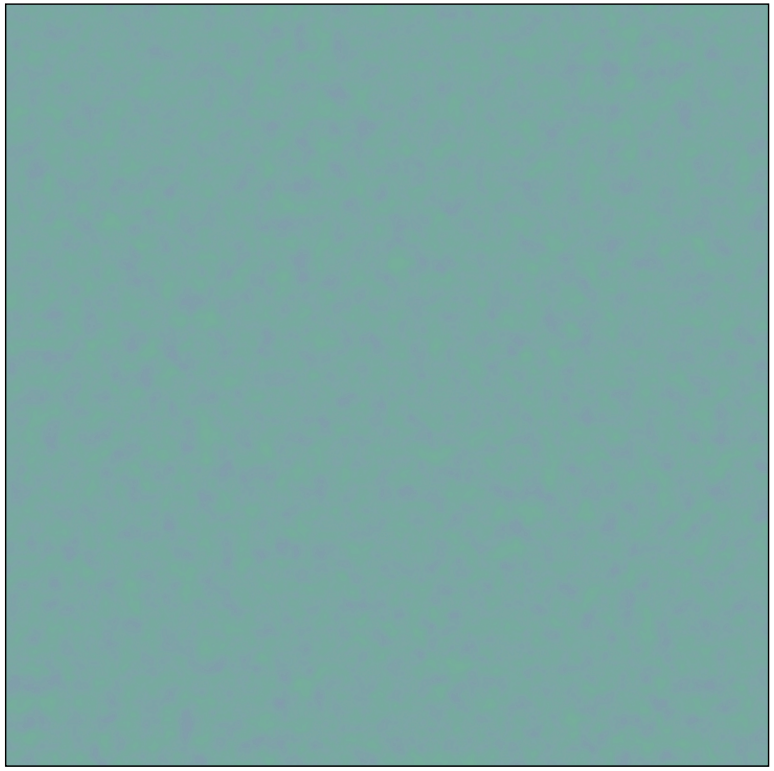
High: **0.85**

Low: **0.25**

Color #1: **R 95, G 165, B 140**

Color #2: **R 115, G 140, B 160**

Note: It's a good idea to give each map/material a unique and significant name to facilitate moving through the material hierarchy. This is particularly useful for complex materials.



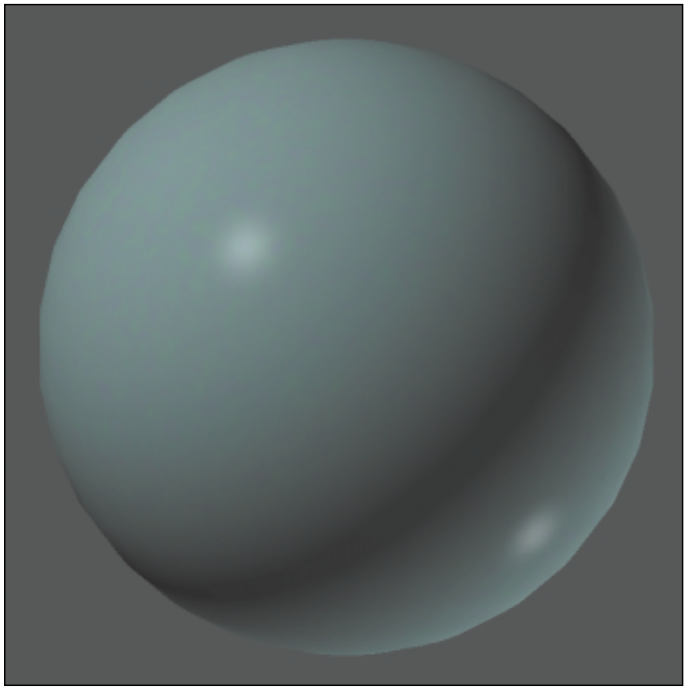
This Noise map will serve as the main coloring for the water material.

5 Go up to the root Water material and set the Diffuse Color to **75%**.

This enables you to mix the Diffuse color set in step 2 with the Diffuse color channel.

6 Set the Reflection channel's amount to **35%**. Apply a Reflect/Refract material to the Reflection channel.

You will use this material to apply reflection mapping to the water based on the surrounding scene objects. When applying automatic reflection mapping, the object's pivot point is used to generate the maps. Because the pivot point of the SuperSpray_Stream particle system is within the faucet and not in a good position to generate Reflection maps, you will create a set of bitmaps based on a temporary object.



Mix the Diffuse color with the Diffuse channel by reducing the Diffuse color amount from 100%.

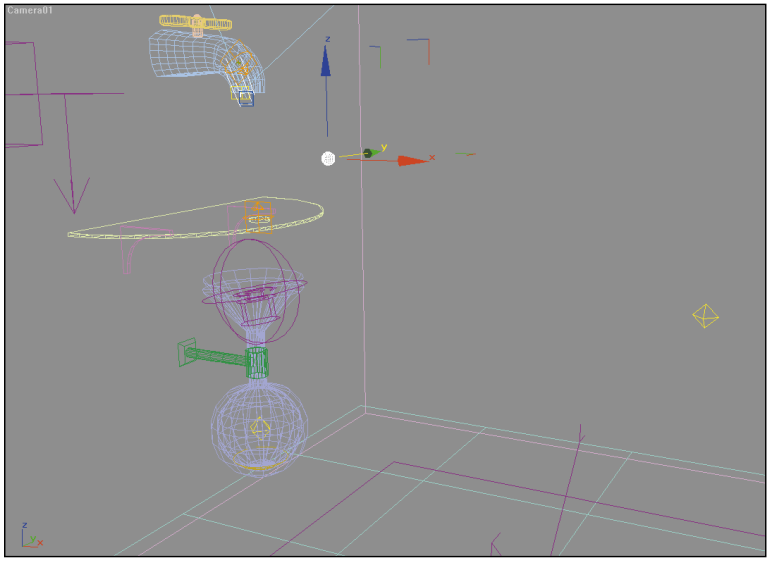
7 Set the Reflect/Refract map's Source to **From File**. Go to the Top viewport and create a Sphere at X = 300, Y = 0, Z = –200. Set Radius to **20**.

8 Under the Render Cubic Map Files section of the Reflect/Refract map, click the To File button. Enter **Water** in the File Name box, set Save as Type to **BMP**, and accept **RGB 24bit** as the BMP Configuration.

Using 24-bit files, as opposed to 8-bit, preserves more color depth information and results in a richer image.

9 Hide the following objects: SuperSpray_Stream, SuperSpray_Splash, and Sphere_Boolean.

This will prevent unwanted objects from showing up in the reflection maps.



The temporary sphere used to create Reflection maps for the water material.

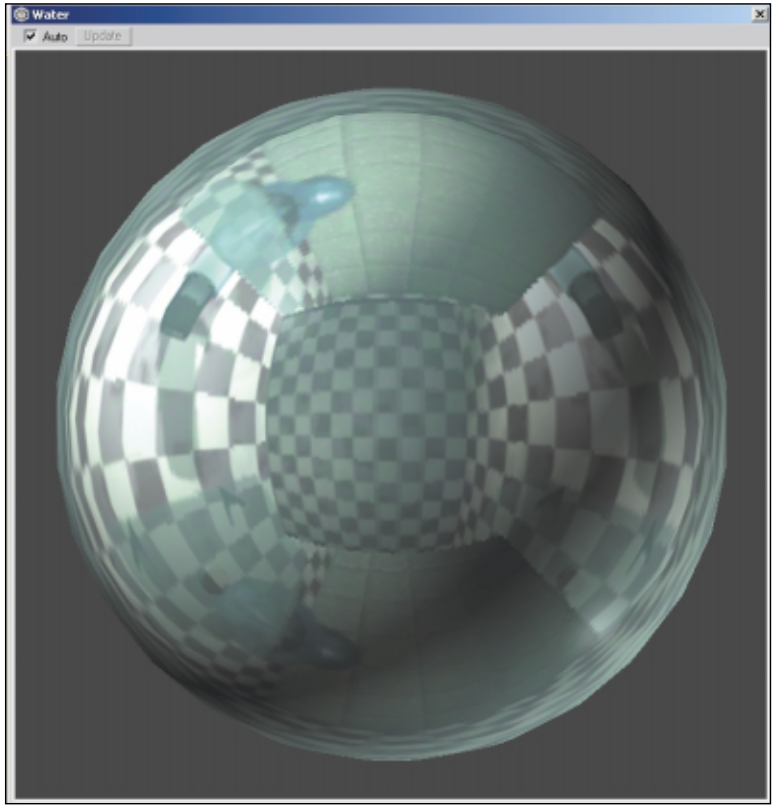
10 Click the Pick Object and Render Maps button and choose the sphere you created in step 8 to render six orthogonal views from the point of view of the temporary object.

3ds max 4 should now render six 100×100 bitmaps and assign them to the Up, Down, Left, Right, Front, and Back slots. Because this set is not a complete room and consists of only two walls and a floor, several of these maps will be flat black. You can change the slot assignments so that all slots have some texture to them.

11 Click the Up slot and choose **water_DN.bmp**. Click the Right slot and choose **water_LF.bmp**. Click the Front slot and choose **water_BK.bmp**. Delete the sphere.

12 Unhide SuperSpray_Stream, SuperSpray_Splash, and Sphere_Water. Assign the Water material to the SuperSpray_Stream particle system.

The six orthogonal views that are automatically rendered using the Render Cubic Maps function.



The finished material as seen in a magnified Material Editor window.

13 Go to the Camera02 viewport, still at frame 35. If you render another still, you will see that the water looks quite a bit more realistic.

14 Assign this material to the SuperSpray_Splash particle system as well.

The final material, applied to the water stream, shown at frame 35.

Material for the Rising Water

The animated Boolean object used for the rising water requires an extra level of materials to separate the rippling top surface from the main body of water.

1 Select an unused material, name it **Rising_Water**, and change the material type to **Top/Bottom**. Set Blend to **15**. Assign this material to the Sphere_Water object.

The Top/Bottom material assigns one of two materials to object faces, depending on whether the face normals are pointing above or below the horizon.

2 Drag the Water material to the Material button for the Bottom material. Choose **Instance** as the method of copying. Rename this material **Water#2**.

3 Drag the Water material to the Material button for the Top material. Be sure to choose **Copy** as the method. Click the Material button for the Top material and rename this material **Water_Surface**.

4 Set the Top material's Bump channel amount to **150** and assign a Mask material to the Bump channel.

5 Assign a Gradient map to the Mask channel, with the following values:

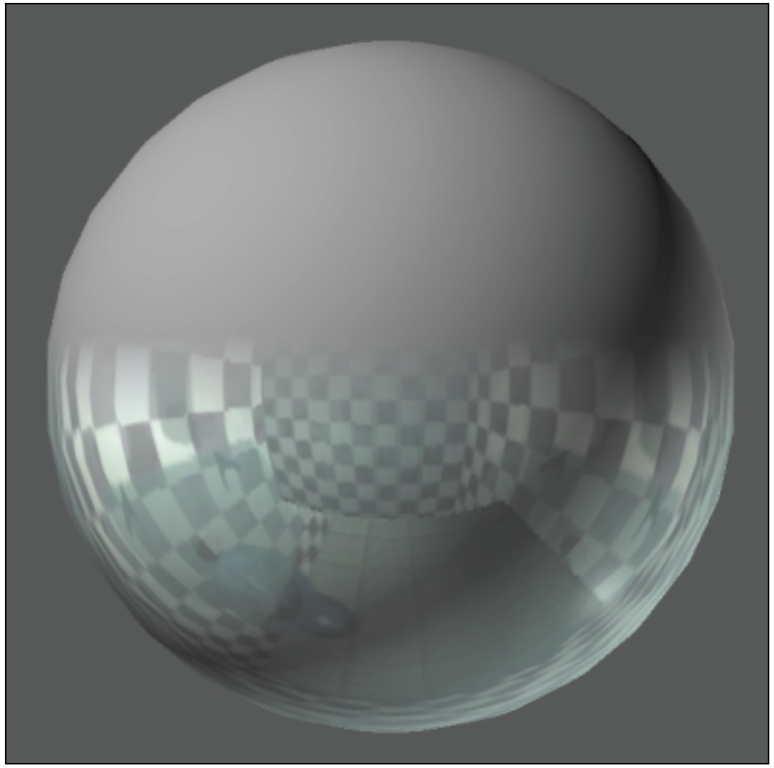
Gradient Parameters
- Color #2: **R 0, G 0, B 0**
- Color 2 Position: **0**
- Gradient Type: **Radial**
- Noise
  - Amount: **0.2**
  - Size: **2**

At this point, the map should appear completely black if you deactivate Show End Result in the Material Editor.

6 Go to frame 200, turn Animate on, and set Phase to **15**.

You will animate this Gradient map to open like a shutter as the water stream hits the surface, adding a ripple bump effect to the water's material.

7 Go to frame 70 and set a key locking the current Color #2 value. The most straightforward way to accomplish this is to open the Color Selector, change an RGB value, and then return to R 0, G 0, B 0.



Assign the Water material to the Bottom channel of the Top/Bottom material.

8 Set the following keys to animate the opening of the shutter:

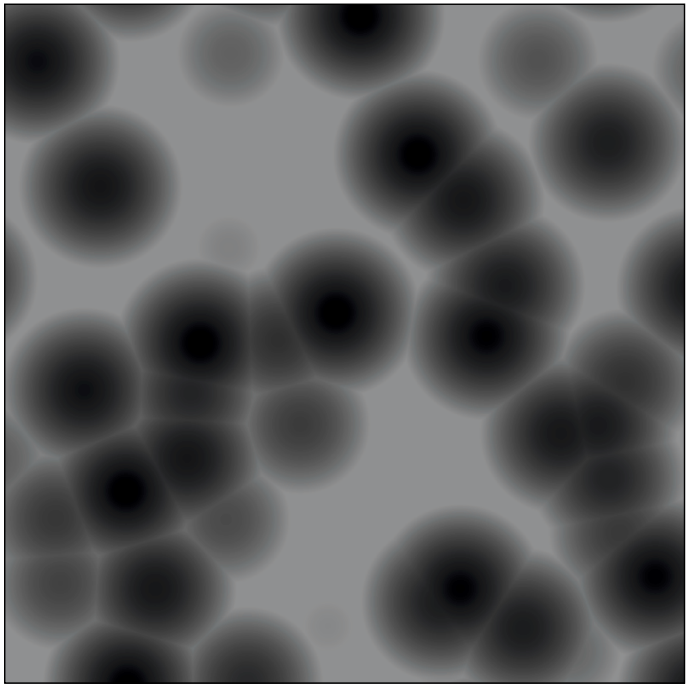
Frame	Color #2
80	R 200, G 200, B 200
105	R 85, G 85, B 85
130	R 0, G 0, B 0

9 Turn Animate off. Go up to the Bump material and assign a Cellular map to the Map slot. Set Source to **Explicit Mapping Channel**.

Note: The Source setting determines how the map is applied to scene objects. The default of Object XYZ applies the map according to the shape of the object in reference to its pivot point. By changing this setting to Explicit Mapping Channel, you apply the map according to whatever UVW channels have been applied either in a UVW Mapping modifier or in an object's creation parameters.

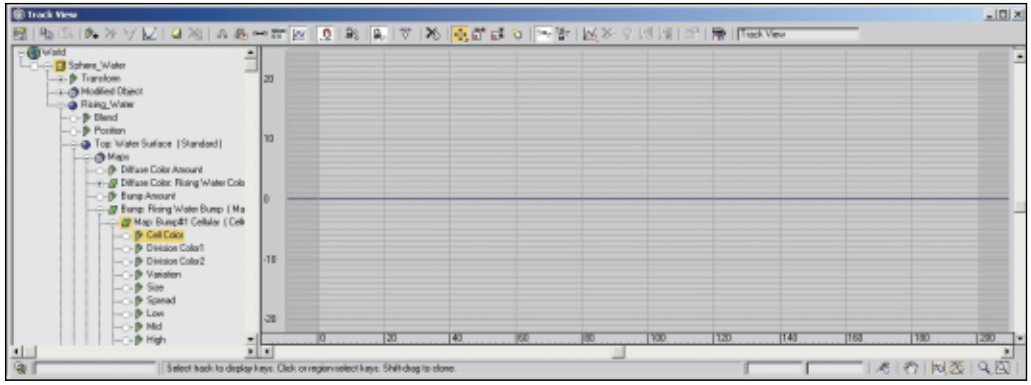
10 Go to the Cellular Parameters rollout and drag the second Division Color onto the first, choosing **Copy**. Under Cell Characteristics, set Size to **0.25**.

You will animate the Cell Color to provide the appearance of rippling water.



Create a Cellular map to provide the look of a rippling water surface.

11 Open Track View and expand the Sphere_Water object to reveal the Rising_Water material track. Continue expanding levels to reveal, in turn, Top: Water_Surface, Bump, Map, and Cell Color. Select the Cell Color track.



Select the Cell Color track, which will determine the height of the water ripples.

12 Assign a Noise Point3 controller to the Cell Color track. Set the following values in the Properties dialog:

X Strength: **256**

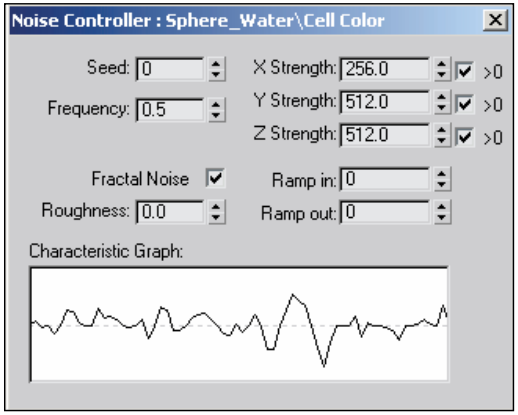
>0: **On**

Y Strength: **512**

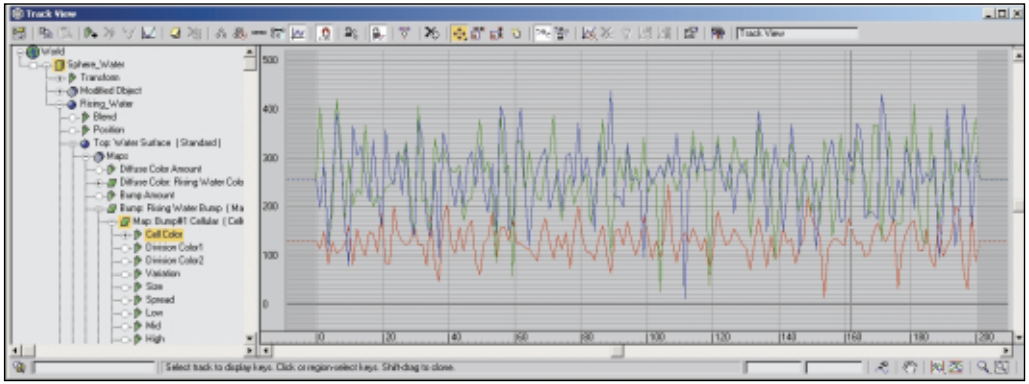
>0: **On**

Z Strength: **512**

>0: **On**



The Noise Controller dialog.



Set the Noise controller's properties to create a consistent degree of variation.

13 Expand Cell Color and choose the Noise Strength track. Go to Edit Keys mode and add keys at frames 75, 110, and 140. Set the following values for these keys:

Frame 75

X Value: **0**

Y Value: **0**

Z Value: **0**

Frame 110

X Value: **1**

Y Value: **3**

Z Value: **3**

Frame 140

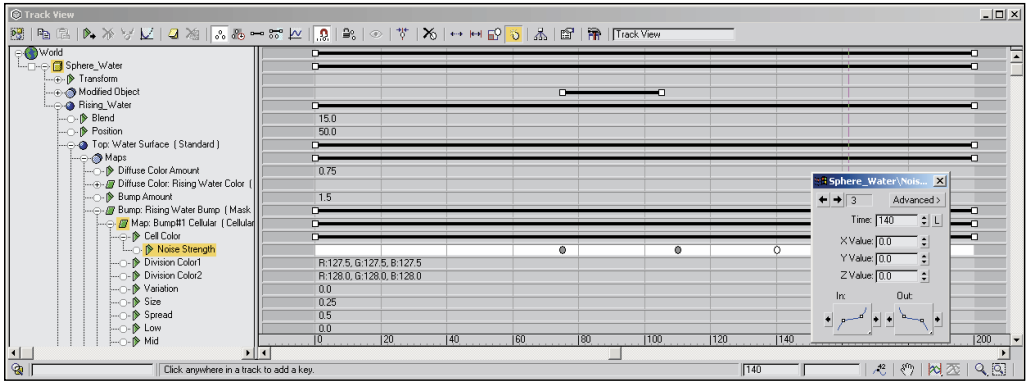
X Value: **0**

Y Value: **0**

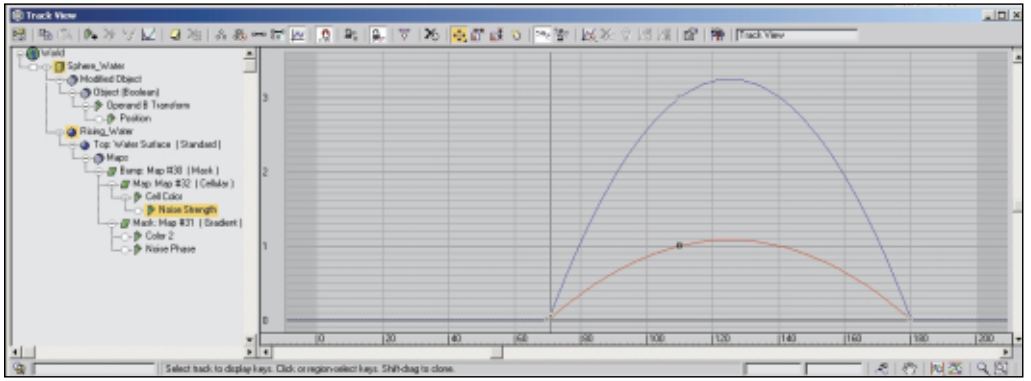
Z Value: **0**

Note: If the Noise Strength track does not show up, go to the Track View Filters dialog and uncheck Show Animated Tracks Only.

Note: Click the left and right arrows in the Key Properties dialog to advance to the preceding or next key.

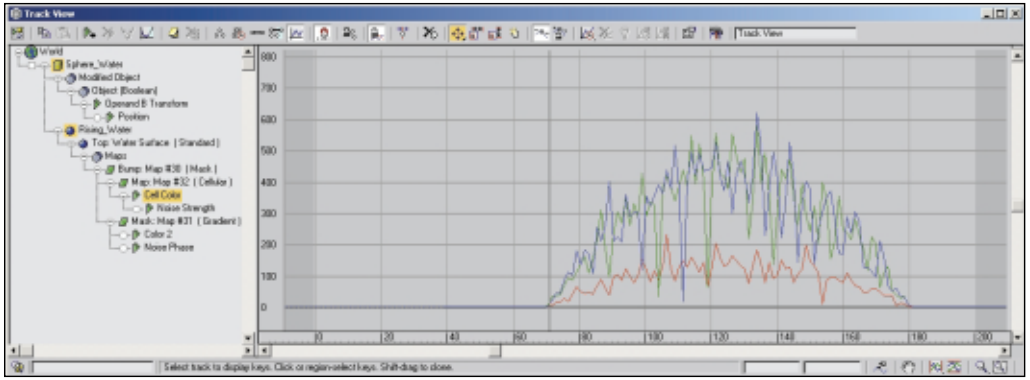


Add keys to the Noise Strength track to vary the agitation of the water ripples.



The Noise Strength track shows how the intensity increases as the water level rises and then settles down.

14 Go to Function Curves mode and select the Cell Color track to see how the curve will ramp up and then down as the surface of the water is agitated by the falling stream.



The Cell Color track as determined by the Noise controller.

RENDERING

The final tweak to add before rendering this sequence is a motion blur. The blur will add to the liquid feel of the water and will smooth out the boundaries between MetaParticles.

1 Select the SuperSpray_Stream and SuperSpray_Splash particle systems, right-click one, and go to the Properties dialog.

2 Ensure that Enabled is on in the Motion Blur section. Select the Object radio button.

This will activate object-based motion blur, which blurs the object according to its motion over time. This is in contrast to image-based motion blur, which blurs the entire image and is more useful for very fast camera moves.

3 Open the Render Scene dialog, open the MAX Default Scanline A-Buffer rollout, and go to the Object Motion Blur panel. Set the following values:

Apply: **On**
Duration (frames): **0.5**
Samples: **5**
Duration Subdivisions: **5**

These settings will blur objects according to their movements over half of a frame, rendering five samples to blend together.

Note: Keeping the Object Motion Blur Samples and Duration Subdivisions settings the same means that all samples will be evenly spaced, avoiding a choppy, random effect that can result when Samples is set to a value less than Duration Subdivisions.

The effect of Object Motion Blur on the water, shown without blur (left) and with blur (right) at frame 36.

MODIFICATIONS

There are many ways in which you could enhance this animation. Additional splash emitters could be placed in the faucet, at the funnel's mouth, or inside the jar itself. Additionally, a particle system emitting bubbles could be used inside the jar. The animated Boolean technique could be used to fill a variety of containers and tubes or to empty them.

The water could be changed to almost any fluid by varying the materials, particularly the Opacity and Diffuse channels. By changing the distribution of the particles, the fluid could be made to spray wildly, trickle slowly, or flow in chunks. The Friction, Bounce, and Chaos settings of the various emitters control how the viscosity of individual droplets is perceived. Increasing Friction will make them appear to be stickier, while increasing the Bounce value will give them a stiff, rubbery feel.