Mastering Revit Plumbing Connectors — AU Edition

An Australian Hydraulic & Plumbing BIM Reference Guide

A companion guide to the WCT-PlumbCheck Sample Revit 2025 Model, WCT-PlumbCheck and WCT-PlumbFlow Revit plugins (obtainable separately), and a standalone reference for Australian hydraulic engineering practice in BIM.

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Standard references: AS3500.1 (Water Services), AS3500.2 (Sanitary Drainage), AS3500.3 (Stormwater Drainage)
Software: Autodesk Revit 2025, WCT-PlumbCheck, WCT-PlumbFlow plugins for Revit 2025

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About This Guide

This guide serves two purposes.

First, as a **standalone BIM reference** — plain-English, AS3500-grounded guidance for setting up compliant plumbing connector data in Revit. Each chapter covers the relevant standard, its correct Revit implementation, the common faults that arise, and the engineering consequences if not configured correctly for flow analysis.

WCT-PlumbCheck, WCT-PlumbFlow (Revit Plugin's) also The source Code for the PlumbFlow application and the WCT- PlumbCheck Sample Revit 2025 Model are available for purchase separately from the website where you obtained this book and are learning tools that represent a working example of the books contents.

Second, as a **tool user manual** — explaining how WCT-PlumbCheck analyses Revit plumbing families and models. Working with the WCT-PlumbCheck Sample Revit 2025 Model and its internal plumbing RFAs, PlumbCheck produces an RFA parts breakdown, complete with explanations and step-by-step sequences that are fully interactive within the sample model.

This guide is written for practising Hydraulic Engineers, Experienced Revit drafters and BIM coordinators — especially those with an interest in software development.

How to use the plugins

For PlumbCheck this is as simple as selecting a plumbing RFA within the sample model and getting a readout of its configuration in a dialog box. The information readout comes with information badges explaining each components setup and functionality.

For PlumbFlow just select either the Stormwater Traversal tool or the Water supply Traversal tool and then select the network for analysis within the sample model

Note: As these are educational tools both Plugins and the Sample Model are synced together. Functionality of the plugins is therefore not available outside of the sample model.

If you have purchased the complete package a link has been provided to the open-source C# code for PlumbFlow. You can use this code for further development with a view to creating your own analytical software plugins

Acknowledgements

Throughout the book you will find references to MAP drafting (**MAP**). Their kind and experienced staff supplied the Revit Template and associated Revit Families available in the sample model. Their RFAs are all built (where detailed information was available) to Australian Standards specifications

I wish to thank MAP Drafting for the enormous and dedicated contribution they have made to this extensive project

The Professional Endgame

Every Australian hydraulic engineer producing a compliant hydraulic services design already knows what the deliverable looks like: a pressure system diagram with an accompanying calculation sheet — fixture flow rates and loading units tabulated by type, a copper pipe sizing table by nominal diameter, pump duty point, available head, and residual pressure at the worst case. This is the document that goes to the certifier, the hydraulic contractor, and the client.

In most cases that calculation is currently produced manually, in parallel with the Revit model, using spreadsheets and engineering judgement. The model and the calculation sit disconnected — a change to one does not update the other.

Yet the Revit model, when configured correctly, already contains every number needed to produce that calculation data — fixture types, loading units, pipe network topology, system flows.

The endgame is not a new deliverable format. It is the existing professional calculation — produced automatically, always in sync with the model, and auditable from first principles against AS3500 and industry-standard formulas.

Revit out of the box, the limitations for Australian design practitioners

In the first chapter we will cover sanitary drainage, as this discipline is the most user-friendly when it comes to Revit interaction. It is the only discipline that aligns with AS3500, in that it uses fixture units for sizing purposes — but unfortunately that is where the association with Australian design practice ends. Revit, in its engineering format for plumbing, caters primarily to the international arena in the form of British and American standards, which also use fixture units for water supply.

The other unfortunate anomaly is that Revit does not recognise stormwater as a plumbing discipline at all, and it is left out altogether. Workarounds are explained in much greater detail in the chapters that follow.

A Word on Parameters

Parameters are a foundational concept in Revit family authoring — they control geometry, drive connector behaviour, populate schedules, and carry engineering data through the model. This guide references parameters throughout, particularly in the context of connector configuration and loading unit linkage.

What this guide covers: which parameters matter for hydraulic compliance, what they could be named, what values they should carry, and why — in the specific context of AS3500 plumbing system modelling.

What this guide does not cover: how to create, manage, or edit parameters in the Revit Family Editor. Parameter fundamentals — the difference between type and instance, family and shared, built-in and user-defined — are assumed knowledge for the reader. Autodesk's own documentation and the broader Revit training ecosystem cover this ground thoroughly, and repeating it here would only dilute the hydraulic engineering content this guide is written to deliver.

Chapter 1 — Sanitary Drainage (AS3500.2)

1.0 Revit MEP Categories — Pipe Fittings vs Pipe Accessories

This section establishes the correct category decision for inline drainage components. It is foundational to every chapter in this guide, and the distinction is non-obvious. Most engineers — and most online resources — in some cases do not understand these principles and/or apply them correctly.

The decision process for RFA's within available Revit plumbing categories

Before we proceed it's important to understand how this book equates the different areas of where to categorise RFAs based on some straightforward principles. Knowing the rules for placement will save a lot of time and frustration as you proceed to build your library of correctly configured plumbing families and their associated connectors

The decision of where we can categorise our families falls into 4 main areas for plumbing

1. Pipe Accessories, an RFA that serves an ancillary purpose other than just conveying flow

2. Pipe Fittings, an RFA that serves only the purpose of conveying flow. A cap is the only exception

3. Plumbing Equipment, an RFA that is plumbing specific but is also connected to a power source

4. Plumbing Fixtures, an RFA that delivers load into the system

(refer fig 1.1)

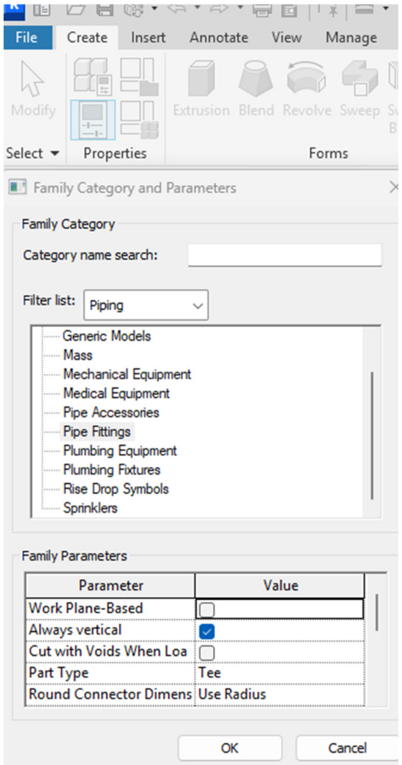


Fig 1.1 Family Category and Parameters within the Create tab, Properties selection ribbon

Two Definitions, One Distinction

By function:

- A **pipe fitting** purely conveys flow. Its sole purpose is to form part of the drainage pathway — a bend, tee, reducer or junction. It has no other role. The role of a cap although contained within the fittings category is the only exception as it may provide access or a future connection point. Also, a cap is essential in telling the Revit accumulation engine which way to direct flow away from an end point in the system such as a vent termination or a clear out to surface

- A **pipe accessory** has an ancillary purpose beyond conveying flow. A valve isolates. A meter measures. A trap excludes sewer gases. An inspection opening provides maintenance access.

By Revit behaviour:

- **Pipe fittings** are inserted automatically by Revit during pipe routing. When two pipes join at an angle, Revit places a bend; when three pipes meet, it places a tee. The engineer does not explicitly place the fitting — Revit does, because it must.

- **Pipe accessories** are placed manually by the engineer, at a deliberate location for a deliberate reason. Revit never inserts them automatically; their placement requires a considered decision.

The behavioural definition is the more reliable test in practice: *who initiates the placement — Revit or the engineer?*

Examples of correct categorisation

For most elements, both definitions give the same answer:

Element	**Function**	**Revit placement**	**Correct category**
Bend / elbow	Conveys flow only	Auto-inserted	Pipe Fittings
Tee / junction / wye	Conveys flow only	Auto-inserted	Pipe Fittings
Reducer / taper	Conveys flow only	Auto-inserted	Pipe Fittings
Isolation valve	Ancillary (isolation)	Manual	Pipe Accessories
Flow meter	Ancillary (measurement)	Manual	Pipe Accessories
Backflow preventer	Ancillary (contamination protection)	Manual	Pipe Accessories
Inspection opening / cleanout in line	Ancillary (maintenance access)	Manual	Pipe Accessories

A detailed example of correct classification **The trap**.

A trap is inline in the drainage pathway — it conveys flow, has no bypass, and is transparent to the network. By the functional definition alone, it could be classified as a fitting. But a trap also has an explicit ancillary purpose: gas exclusion. A disconnector trap, gully trap or floor waste trap prevents sewer gas from escaping into the habitable space. This is not incidental — it is the primary reason the trap exists at that location in the design.

And critically, the engineer places the trap deliberately, at a specific point. Revit never auto-inserts one.

By the Revit behaviour definition — the more reliable test — a trap belongs in Pipe Accessories.

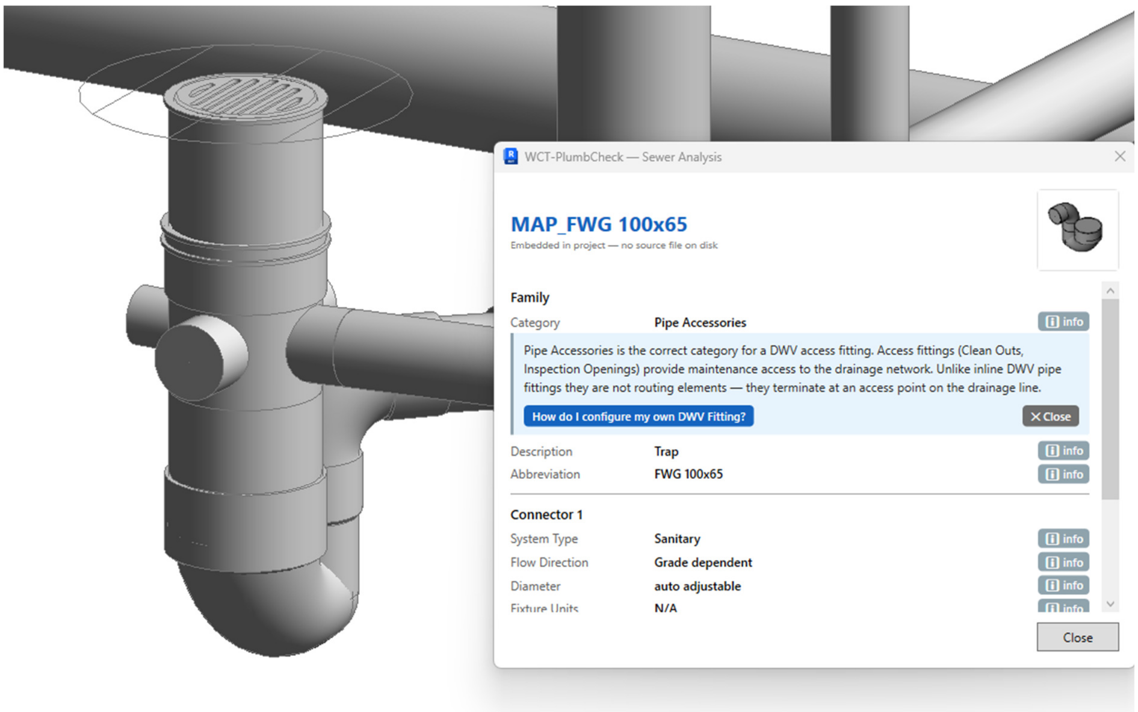
Element	**Ancillary purpose**	**Revit placement**	**Correct category**
Trap (disconnector, gully, floor waste with integrated trap)	Yes (gas exclusion)	Manual	Pipe Accessories

Implications for the WCT-PlumbCheck Plugin

When PlumbCheck detects a family in Plumbing Fixtures with two connectors (one in, one out), it flags it as a pass-through element in the wrong category. The correct destination is not always Pipe Fittings — it depends on the element:

- A pure routing coupler or pass-through fitting with no ancillary function → **Pipe Fittings**
- A trap, inspection opening, or any element with a function beyond flow conveyance → **Pipe Accessories**

For fixture-unit accumulation, both Pipe Fittings and Pipe Accessories support the sanitary-first connector setup sequence (see Section 1.2). The category choice determines how Revit treats the element in schedules, view filters and routing automation — not whether it can accumulate fixture units through the network.



Resulting Analysis from the PlumbCheck plugin when run on the MAP Floor Waste Gully RFA embedded within the sample model

Summary — The Defining Test

Does Revit place this automatically during pipe routing?

- **Yes** → Pipe Fittings
- **No** → ask whether it has a purpose beyond conveying flow
  - **No ancillary purpose** → Pipe Fittings
  - **Ancillary purpose** → Pipe Accessories
  - **Pipe cap** → Pipe Fittings (As Revit can't auto place it otherwise)

Verified: FU Accumulates Correctly in Pipe Accessories

Testing confirms that Revit's fixture-unit accumulation engine reads the stored connector configuration from the sanitary-first sequence regardless of whether the family is categorised as Pipe Fittings or Pipe Accessories. A trap correctly configured and placed in Pipe Accessories accumulates fixture units through the drainage network exactly as a Pipe Fittings family does.

This validates the engineering logic: the category choice governs Revit's scheduling, routing automation and filter behaviour — not fixture-unit accumulation capability. Both categories are fully supported.

The Two-Phase Setup Procedure for Pipe Accessories

There is one constraint: the sanitary-first connector setup sequence must be performed **while the family is in the Pipe Fittings category**. Revit only exposes the required flow accumulation fields (Flow Direction, Flow Configuration) on connectors when the category is Pipe Fittings. Attempting the setup directly in Pipe Accessories will not activate the accumulation fields correctly.

The correct procedure for any element whose final category should be Pipe Accessories is as follows.

Phase 1 — Activate flow accumulation (must be in Pipe Fittings)

1. Family Editor → Create tab → Properties panel → Family Category and Parameters
2. Set category to **Pipe Fittings**
3. Apply the full sanitary-first connector setup to both connectors *(see Section 1.2)*

Phase 2 — Set the correct final category
4. Family Editor → Create tab → Properties panel → Family Category and Parameters
5. Set category to **Pipe Accessories**
6. Save the family (Ctrl + S)
7. Modify tab → Load into Project → overwrite when prompted

The stored connector configuration from Phase 1 persists through the category change in Phase 2.

1.0a Embedded Families — Why They Are Problematic for Software Developers

What Is an Embedded Family?

When a Revit family is loaded into a project without first being saved to a folder on disk, Revit stores the entire family definition inside the project file itself. These families are described in the Properties panel as *"Embedded in project — no source file on disk."* They are sometimes called **project-embedded** or **in-place loaded** families.

This happens routinely: a drafter downloads a manufacturer's RFA, loads it directly into a project without saving it to the office library, and moves on. The family works — it inserts, it connects to pipes, it looks correct. The problem stays invisible until something needs to change.

Why Embedded Families Break Software Write-Back Tools

A Software Plugin — and any other Revit API tool that needs to update a family's parameters — relies on being able to open the source RFA file, make changes, and reload it into the project. For embedded families, there is no source file. The Revit API does provide a path to open an embedded family via EditFamily(), but the results are unreliable:

- Revit's built-in ALL_MODEL_DESCRIPTION parameter — the Identity Data > Description field visible in the Properties panel — is read-only through the API when accessed on the family element in a project context. Writing to it in the Family Editor document and reloading via LoadFamily() does not propagate the change back to the project.
- The only reliable persistence path for embedded families is Revit's own Family Editor interface, where the engineer makes the changes manually and uses *Load into Project* to overwrite the existing version.

Consequence: A plugin cannot update for example the Description parameter on an embedded Plumbing Fixtures family. The QC check fires correctly — the blank or unrecognised description is flagged — but the tool cannot complete the correction. The engineer must save the family to disk first.

Why Embedded Families Are a Broader Risk

The write-back limitation is the most immediate symptom, but it reflects a deeper problem with embedded families in a production BIM environment.

No version control. An embedded family has no known origin. If the same family exists in your office library and has since been corrected or updated, the project is still using the old version — with no indication that a newer one exists.

No reuse. The family is trapped inside one project file. To use it in another project, someone must first export it with *Save As* from the Family Editor. Without that deliberate export step, the family never makes it into the shared library, and the next project starts from scratch.

No audit trail. You cannot determine who created it, when, or whether it was ever reviewed against your office standard. An embedded family has effectively escaped the quality control process.

WCT-PlumbCheck Sample Model comes with embedded families by default as its for educational purposes only, however if software development or reuse of some of the example RFAs carried within the model is your goal then It is strongly recommended that saving those components to your Revit library be executed as a first step principle prior to editing or testing

The Correct Working Practice

Every family used in production should have a source RFA file in a managed location — whether a local office library, a shared drive, or a project-specific family folder. The workflow is:

1. Receive or create the RFA file
2. Review and configure it
3. Save it to the office library or project family folder
4. Load it into the project from that saved file

If embedded families already exist in a project, the recovery path is:

1. Right-click the family instance → *Edit Family*
2. *File → Save As* — save the RFA to a managed folder
3. *Modify tab → Load into Project* — this re-links the project's version to the saved file

After this process, your own plugin write-back features should work correctly — descriptions can be set, parameters can be verified, and the family is now part of the managed library.

1.1 DWV Drainage Fittings — Connector Configuration

The Role of Fittings in the Drainage Network

A DWV (drain, waste and vent) drainage network is built from two distinct element types: **fixtures**, which originate waste flow, and **fittings**, which route it. Bends change direction. Junctions collect branches. Reducers transition pipe size. Caps terminate branches or provide cleanout access.

Fittings carry no load of their own. They do not generate fixture units and they do not add litres per second. Their sole analytical function is to form the **connective pathway** through which flow accumulates from fixtures toward the discharge point. Get the fittings wrong and the network has no coherent pathway — the traversal engine cannot walk it, flow cannot accumulate, and any downstream sizing calculation becomes impossible.

This is the drainage equivalent of the water-supply connector quality argument: correct connector configuration on fittings is the prerequisite that makes all analytical tools possible.

One Fitting, Two Disciplines

The most practically important characteristic of Australian DWV fittings is that the same physical fitting is used in both **sanitary drainage** (sewer) and **stormwater** networks. A PVC DWV bend installed on a soil stack is structurally identical to one installed on a rainwater downpipe. Manufacturers supply them interchangeably.

This creates a Revit configuration choice: which system type should a DWV fitting's connectors be set to?

The correct answer is **Fitting (Revit system classification integer: 28)**.

Fitting is Revit's "inherits from the connected network" classification. An RFA configured as “Fitting” adopts the system type of whatever pipes it is connected to — Sanitary in a sewer network, OtherPipe can be used in a stormwater network — without any change to the family definition, but the most common is to assign it to Sanitary for fittings insertion. The same family, loaded once into a project template, serves both disciplines correctly.

The alternatives — configuring fittings as Sanitary (16) or OtherPipe (22) — lock the fitting to a single discipline but this can create mismatches when the same family is used in the “Other” context and is a common source of connector warnings in Revit models.

Rule: All DWV drainage fittings must use system classification “Fitting” (28).

Fitting Type Identification

Fitting type is determined entirely by connector count, combined with the diameter relationships between connectors. WCT-PlumbCheck uses the following logic:

Connector count	Diameter relationship	Fitting type
1	—	Cap / Cleanout
2	Both equal	Bend / Elbow
2	Unequal	Reducer / Taper
3	Index 0 = Index 2, Index 1 ≤ Index 0	Junction / Tee
4+	—	Multi-inlet riser (e.g. 4-way riser)

Connector index conventions follow the Revit API order returned by the ConnectorManager for that family.

Fitting-Specific Rules

Cap / Cleanout (1 connector)

A cap terminates a pipe end; a cleanout cap provides maintenance access. Both have exactly one connector. No diameter relationship rules apply — the single connector matches the pipe it terminates.

Common use: cleanout access to surface (IOS).

Bend / Elbow (2 connectors, equal diameter)

A bend changes direction. Both connectors must be the same nominal diameter — a bend does not reduce. The two connectors are geometrically opposed, and Revit's fitting geometry coupling handles the angular variation.

Common use: direction changes in horizontal runs, offsets around structure, stack offsets.

Reducer / Taper (2 connectors, unequal diameter)

A reducer transitions from one pipe diameter to a smaller one. The two connectors must be different nominal diameters. In AS3500.2 drainage practice, the preferred fitting is a **level-invert taper** — the invert (bottom) of the pipe is held at a constant elevation through the transition rather than the centreline. This maintains a continuous flow gradient through the reduction.

Note: level-invert versus centreline alignment is an installation and specification requirement. It cannot be validated from connector data and is addressed in design documentation and specification clauses.

Junction / Tee (3 connectors)

A junction collects flow from a branch into a main run. The run connectors (index 0 and index 2) must be equal diameter. The branch connector (index 1) must be equal to or smaller than the run diameter — a branch cannot be larger than the run it discharges into. An equal junction (all three the same size) is valid.

Common use: branch connections to mains, WC connections to soil stacks, floor drain branches.

Fittings and Fixture Units

DWV drainage fittings contribute **zero fixture units**. This is a fundamental principle.

Fixture units (FU) are a measure of *demand load* — they quantify the probability that a fixture is discharging at a given moment. The load originates at the fixture: the WC, the Basin, the Shower drain. A fitting routes that load through the network; it does not originate any.

The consequence for BIM analysis is that drainage fittings require no FU parameters, no LitresPerSecond parameters, and no flow formula linkages. They are transparent traversal nodes. In the case of Stormwater a traversal engine is required which can walk through fittings unconditionally, accumulating flow only when it reaches a fixture family e.g. Rain Water Outlet (RWO) that carries a flow parameter. An example of a Stormwater Traversal plugin is given in the PlumbFlow application and its associated open-source code

This holds for both disciplines:

Discipline	Load originates at	Fittings role
Sanitary drainage	Fixture (Fixture Units)	Transparent traversal node
Stormwater	Rainwater outlet (LitresPerSecond)	Transparent traversal node

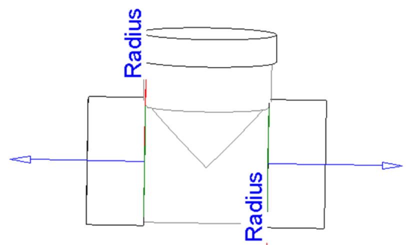
The same fitting family, with the same connector configuration, supports both sizing workflows. This is only possible because the connectors are correctly set to “Fitting” (28).

Summary — Minimum Connector Requirements for DWV Fittings

Property	Required value
Revit category	Pipe Fittings
System classification	Fitting (28)
Flow direction	Not set (result of sanitary-first setup — the row value displays "Not set"; PlumbCheck shows "Grade dependent" as the ⓘ info-badge explanation, not as the row value itself)
Connector count	Matches fitting type (1 / 2 / 3 / 4)
Diameter relationship	Matches fitting type (see table above)
FU parameters	None required

A fitting that meets these requirements is analytically transparent — the traversal engine can walk through it in any direction, in any discipline, and accumulate the correct flow to the discharge point.

1.2 Pass-Through Drainage Fittings — Fixture Units and the Sanitary-First Setup Sequence



The Problem

A **pass-through drainage fitting** is a family that acts as an inline component between a floor waste, gully or trap and the drainage pipe network. Common examples are disconnector traps, floor gullies with integrated traps, and cleanout access fittings with in-and-out connections. These families have two piping connectors — **one inlet and one outlet** — and they live in the gravity drainage network alongside conventional DWV bends and junctions.

The critical difference between a pass-through fitting and a simple DWV fitting is that flow accumulation **must pass through it**. Fixture units generated by connected fixtures above must travel through the fitting's outlet connector and into the downstream pipe. If the connector is not correctly configured, the fixture units are silently dropped — no error is shown in Revit, the pipe network looks connected, but the accumulation calculation is missing those fixtures' load.

This is one of the most common and least visible sources of incorrect FU accumulation in Revit drainage models. No warning appears; no visual indicator is present. The network traversal simply stops at the misconfigured connector and continues to the next path.

The Root Cause — System Classification and Flow Direction

Revit's FU accumulation engine reads fixture units only from connectors that meet two conditions simultaneously:

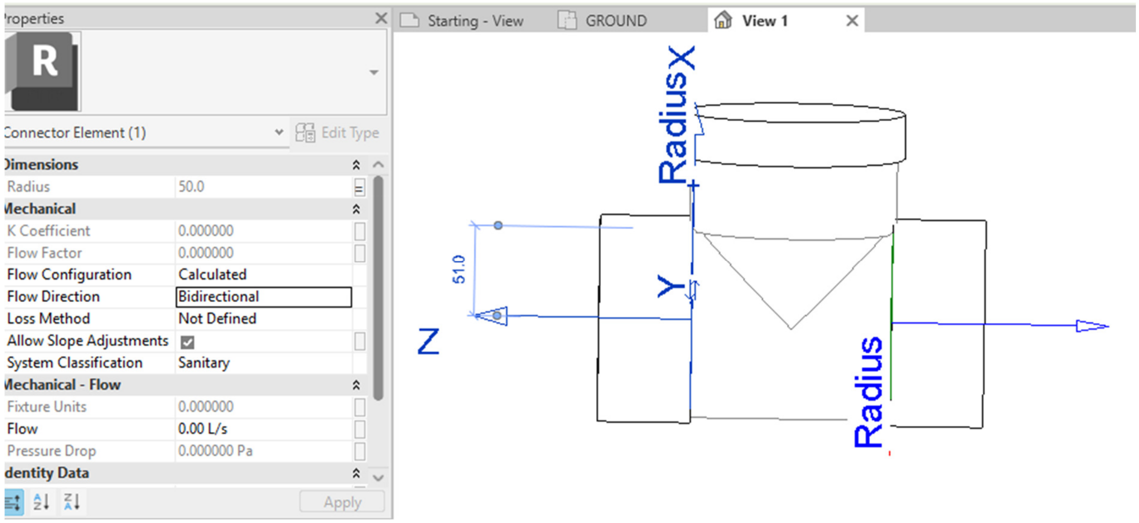
1. **System Classification = e.g. Sanitary** (system type integer 16)
2. **Flow Direction = e.g Out** (direction integer 2)

A connector that does not meet both conditions is invisible to the accumulation engine. This creates a paradox for pass-through fittings: they should ultimately be configured as **Fitting** (“Fitting”, system classification 28) so that they inherit the connected pipe network and work across both sanitary and stormwater networks. But a connector set directly to Fitting carries no fixture units.

The resolution is a specific setup sequence that exploits the order in which Revit stores connector properties.

The Sanitary-First Setup Sequence

Both connectors on a pass-through drainage fitting must be configured using this sequence.

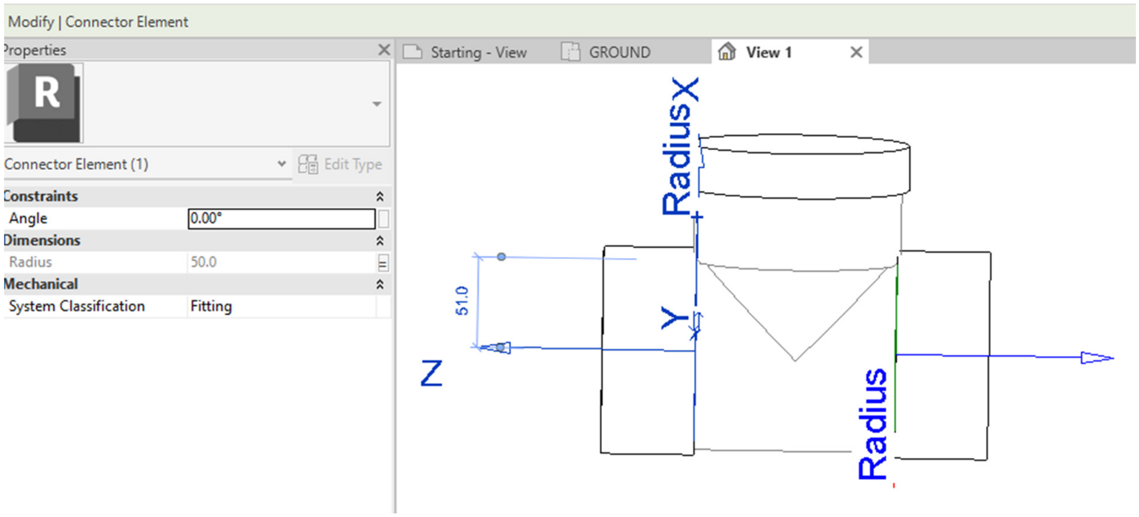


INLET connector:

1. Set System Classification to **Sanitary**
2. Set Flow Direction to **Bidirectional (**for pass through fittings)
3. Set Flow Configuration to **Calculated**
4. Tick **Allow Slope Adjustment**
5. Change System Classification back to **Fitting**

OUTLET connector:

1. Set System Classification to **Sanitary**
2. Set Flow Direction to **Bidirectional (**for pass through fittings)
3. Set Flow Configuration to **Calculated**
4. Tick **Allow Slope Adjustment**
5. Change System Classification back to **Fitting**



The explanation: the Sanitary step activates Revit's flow accumulation fields on the connector. Setting the direction and flow configuration while the connector is in the Sanitary state writes those properties into Revit's internal data store in a way that persists after the system classification is changed back to Fitting. Revit's accumulation engine then reads the stored configuration and treats the outlet as a valid FU accumulation point. Switching back to Fitting allows the connector to inherit the connected pipe network in the project — making the same family usable in both sanitary and stormwater networks without modification.

This behaviour is not prominently documented in Autodesk Help. It is discovered knowledge, confirmed through testing against live Revit models.

The API Limitation — PlumbCheck Cannot Verify Completion

After the sanitary-first setup sequence is completed correctly, reading the connector state through the Revit API returns:

- System Classification: **Fitting** (GenericFitting) — displayed as "Sanitary" or "Stormwater" in PlumbCheck, read from the live connected pipe
- Flow Direction: **Not set** — the Flow Direction parameter is null after the sequence; PlumbCheck shows **"Not set"** in the row value, and the ⓘ info badge explains this as **"Grade dependent"** to convey the engineering meaning: gravity drainage fittings have no fixed flow direction, as flow follows the pipe grade
- Fixture Units: **Not set** — displayed as **"Pass through"** in PlumbCheck; fittings carry no FU load, they pass accumulated load from upstream fixtures through to the discharge point

This is **identical** to a connector that was never configured at all. Revit stores the flow accumulation data internally in a way that is not exposed through the standard ConnectorElement parameters readable by the API. The stored direction and flow configuration from the Sanitary step are invisible to external tools.

Consequence: WCT-PlumbCheck cannot distinguish between a correctly configured pass-through fitting and an unconfigured one. Both present as GenericFitting | Not set from the outside.

What PlumbCheck **can** detect is the starting condition — a family in the Plumbing Fixtures category with more than one connector. This is the topology mismatch that indicates a pass-through fitting has been placed in the wrong category.

What the clean result means: after the engineer:

1. Changes the family category to Pipe Fittings (or rebuilds in the correct template)
2. Completes the sanitary-first setup sequence on both connectors

WCT-PlumbCheck will show **no WARNs**. This is the correct and expected outcome. The clean display is the signal that there is nothing to flag — not that the setup cannot be verified. The only proof that the accumulation is working correctly is in the live Revit model: fixture units should be accumulating through the fitting once pipes are connected and fixtures are placed.

Correct Revit Category for Pass-Through Elements

Pass-through drainage elements belong in **Pipe Fittings** or **Pipe Accessories** — not Plumbing Fixtures. The correct category depends on the element's purpose (see Section 1.0):

- **Pipe Fittings** — auto-inserted by Revit during routing; purely conveys flow. Examples: bend, reducer, tee.
- **Pipe Accessories** — manually placed by the engineer; has a purpose beyond flow conveyance. Examples: disconnector trap (gas exclusion), inspection opening (maintenance access).

Fixture units accumulate correctly through both categories when the sanitary-first setup is applied. For Pipe Accessories, the setup must be performed while the family is temporarily set to Pipe Fittings — see Section 1.0 for the two-phase procedure.

Note: Revit does not allow category changes within an existing family file directly in some versions. If the category dropdown is unavailable, the family must be rebuilt from the correct template (File → New → Family → select the Pipe Fitting or Pipe Accessory metric template).

Inspection Openings and Cleanouts

A drainage cleanout (IO — Inspection Opening Sewer) with inlet and outlet is always a **Pipe Accessories** element — its defining function is maintenance access, not flow routing. However, the connector count determines its role in the network and how it must be configured:

Connector count	**Role**	**Flow accumulation**	**Configuration required**
1 connector	Stub cleanout — access point only	None — sealed, no flow	Set as Fitting - Cap
2 connectors (inlet + outlet)	Inline cleanout — conveys flow	Yes — sanitary-first sequence applies	Full two-phase setup required

The rule is straightforward: the connector count tells you everything.

A stub cleanout with one connector joins the drainage network as a branch terminal. The cap is sealed — no waste flows through it under normal conditions. It carries no WFU value and requires no flow accumulation configuration. PlumbCheck will not flag a single-connector Pipe Accessories family for missing FU linkage.

An inline cleanout with two connectors sits in the flow path — waste passes through it between the inlet and outlet. It must be configured with the sanitary-first sequence (Section 1.2) to ensure fixture units accumulate correctly through it. Treating it as a stub (single connector) in the model would break the accumulation chain at that point.

Practical note: these are two distinct RFAs serving two distinct purposes. A single family cannot correctly serve both roles. Engineers should ensure the correct variant is selected when modelling — a stub cleanout placed where an inline cleanout is needed (or vice versa) will produce silent errors in FU accumulation that PlumbCheck cannot detect at the family level.

Multi inlet connector elements. (DWV Fittings Tees, Junctions, 4 Way risers)

Topology

A junction is a DWV fitting with three or more pipe connectors. The most common form is a standard tee — one inlet from a branch fixture, one continuing run inlet, and one outlet to the downstream drain. Four-connector fittings (e.g. 4 way risers) follow the same principle with additional inlet ports.

PlumbCheck identifies the fitting type from connector count:

Connector count	Fitting type	Typical use
1	Cap	Pipe terminus, stub cleanout
2 — equal diameters	Bend	Change of direction
2 — unequal diameters	Reducer	Pipe size transition
3	Junction	Branch connection (tee, wye)
4+	Multi-inlet riser	Stack or multi-branch connection

Flow Direction — Why Junctions Are Directional

Bends and reducers use Bidirectional connectors — flow can enter and leave from either end, and the fitting is symmetric. A junction is different. In a gravity drainage system the slope determines which pipe is downstream, and the junction fitting encodes this analytically:

- Two inlet connectors (In) — the branch pipe and the continuing upstream run
- One outlet connector (Out) — the downstream drain run

This In/In/Out configuration is not a restriction on how water flows physically — it is the analytical definition that tells Revit's MEP accumulation engine which connector receives aggregated FU from both inlets and passes it downstream. Without this directionality, the engine cannot correctly attribute the combined fixture load to the outlet pipe.

Setting both inlet connectors to In and the outlet connector to Out is therefore compulsory for a correctly functioning DWV junction. A junction with all-Bidirectional connectors will visually connect to pipes in the model but will silently break FU accumulation at the branch point.

The correct Part Type for a three-connector junction is Tee (set in the Family Editor under Part Type → Tee). The Part Type drives Revit's routing and snap behaviour — a Tee will receive a branch pipe at the correct port, whereas an incorrect Part Type will cause unexpected routing.

Parameters — What a DWV Junction Needs and Does Not Need

What a junction does not need:

A DWV fitting carries no fixture load of its own. It conveys accumulated load from upstream fixtures through to the downstream network. No drainage fixture unit (WFU) parameter is required on the fitting family — none should be added, linked, or populated. PlumbCheck will not flag the absence of a FU parameter on a fitting as a warning; it is the expected and correct condition.

What a junction does need:

Parameter	Purpose	Notes
Connector diameters	Define the pipe sizes the fitting connects to	Linked to a family type parameter for multi-size variants (e.g. 100×100×100, 150×100×150)
Radius	Controls the fitting's internal geometry and centre-line curve	Link to a parameter for flexibility — Revit uses this for routing calculations
Part Type	Identifies the fitting to Revit's routing engine	Set to Tee for a three-connector junction
System Classification	All connectors set to Fitting via the sanitary-first sequence	Inherited from the connected pipe network at placement

Multi-size variants:

A junction family typically covers multiple size combinations as family types — for example, a 100×100×100 equal junction and a 100×65×100 reducing junction as separate types within the same RFA. Each type has its own connector diameter values. The diameters should be type parameters (not instance parameters) so that Revit can select the correct type during automatic routing.

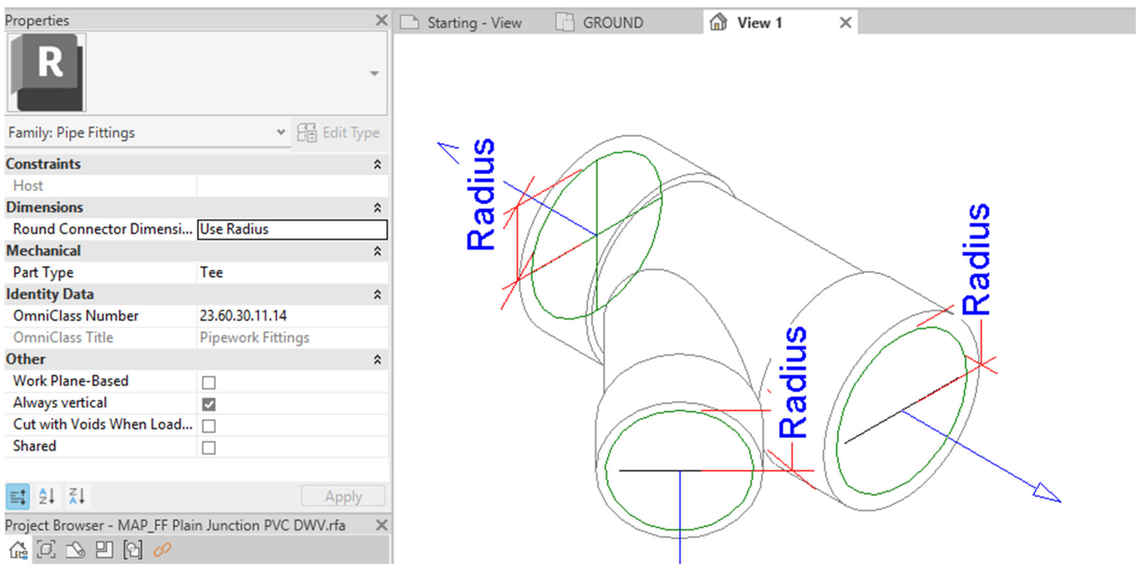
Reducing junctions:

Where the branch inlet diameter differs from the run diameter, PlumbCheck identifies the fitting as a Junction regardless — the three-connector count takes precedence over diameter equality. The branch inlet is typically the smallest connector. PlumbCheck does not validate which connector is smallest or enforce a specific branch/run relationship — the connector count and system classification (GenericFitting, Not set) are the checks that matter.

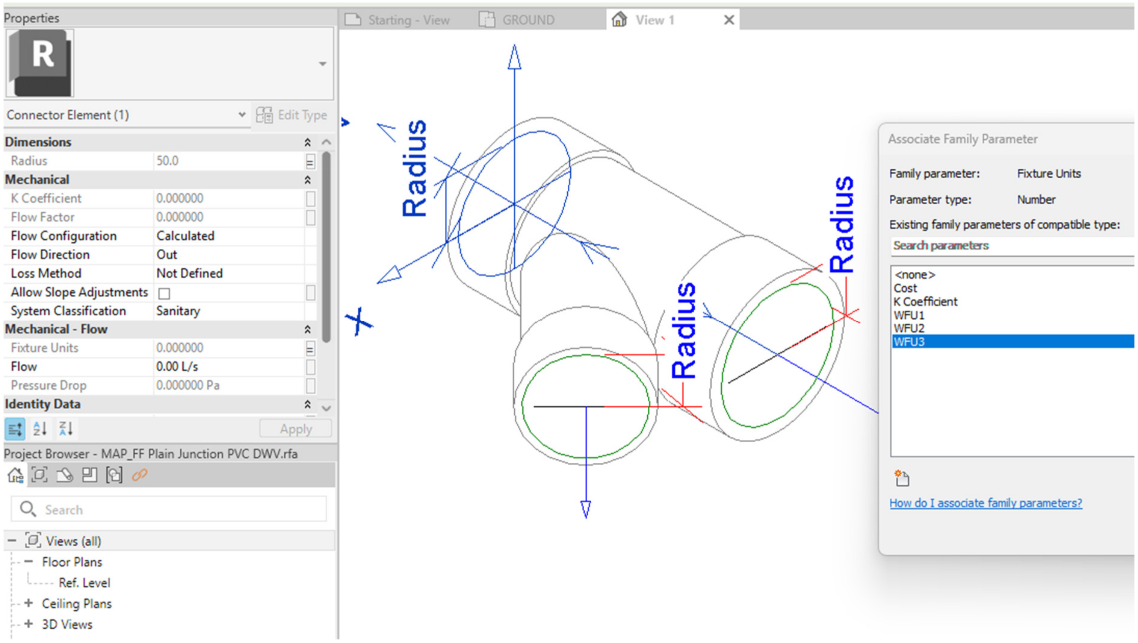
The Zero-FU Principle for Fittings

No DWV fitting — bend, reducer, junction, or multi-inlet riser — carries or stores fixture unit data. The FU value visible on a pipe segment in Revit represents the accumulated load from all fixtures connected upstream of that pipe, passed through fittings that are analytically transparent. The fittings are invisible to the accumulation engine in terms of load; they exist only as a path.

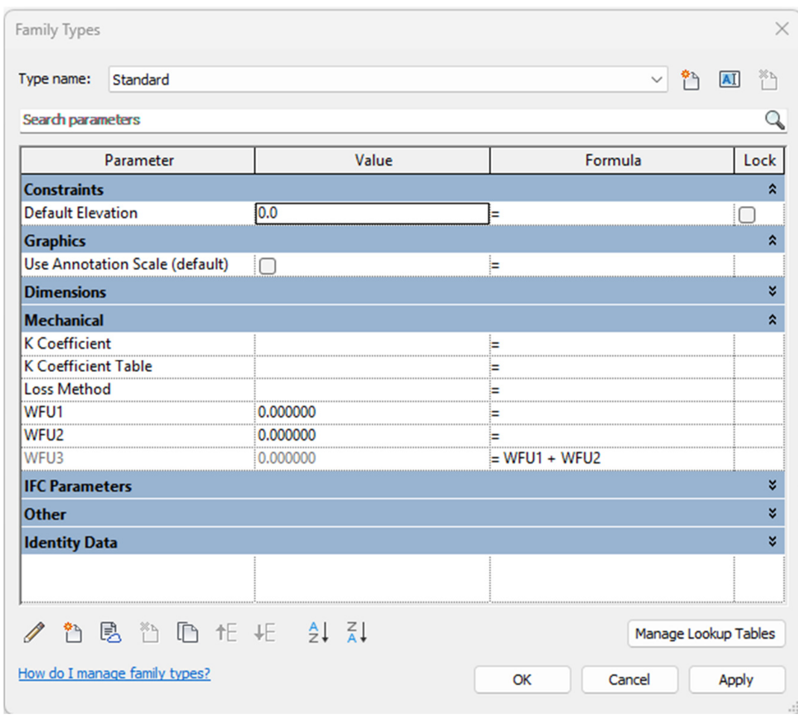
This is why PlumbCheck shows "Pass through" and "N/A" for the Fixture Units row on DWV fittings rather than flagging the absence of a FU parameter as a warning. The absence is not a gap — it is the correct configuration.



A Junction is part type “Tee” within the family category “Pipe Fittings”



The Junction with its Outlet connector highlighted and its Associated Family Parameter WFU3 shown



The Junctions parameters linked to a Formula WFU3 (outlet) = the sum total of inlets WFU1 + WFU2

Summary

Condition	PlumbCheck result	Meaning
Plumbing Fixtures + multiple connectors	HELP — topology mismatch	Wrong category — recategorise to Pipe Fittings or Pipe Accessories
Pipe Fittings + GenericFitting | Not set	No WARNs	Correct final state ✓
Pipe Accessories + GenericFitting | Not set	No WARNs	Correct final state if the two-phase procedure was followed — PlumbCheck cannot verify Pipe Accessories connector state; confirm via live-model FU accumulation
Pipe Fittings + Sanitary | Bidirectional	HELP — setup incomplete	Sanitary-first sequence not completed
Pipe Accessories + Sanitary | Bidirectional	No WARNs — undetected gap	PlumbCheck does not validate Pipe Accessories connector state — fittingNeedsConfig is gated to Pipe Fittings only; misconfigured Pipe Accessories pass silently, and the two-phase procedure must be completed manually

The sanitary-first sequence leaves no readable trace in the connector parameters accessible via the Revit API. For Pipe Fittings, the absence of WARNs confirms the connectors passed the GenericFitting | Not set check. For Pipe Accessories, PlumbCheck does not validate connector state at all — no WARNs will appear regardless of whether the two-phase procedure was completed. In both cases, verification of FU accumulation must be confirmed in the live model.

1.3 Phantom MEP Connections — Silent FU Loss After Family Reload

What Is a Phantom MEP Connection?

A **phantom MEP connection** is a condition where a pipe and a fitting appear visually connected in a Revit view — the pipe end meets the fitting body, and no gap is visible — but the MEP analytical network does not register the connection. Fixture-unit accumulation stops at the element as though the pipe were not there. No warning is issued by Revit, and the network looks correct in every view.

The term "phantom" refers to the visual presence without analytical substance: the connection you can see is not the connection the FU calculation engine actually uses.

Case Study — MAP_GULLY 100

This condition was identified during live-model testing of a floor gully family (MAP_GULLY 100) that had been through a category-change workflow:

- A shower fixture (Plumbing Fixture, 1 FU) drained into the gully via a short vertical pipe stub
- The gully drained horizontally into the downstream drainage network
- The gully had been correctly configured via the sanitary-first procedure (Section 1.2), confirmed by Fitting | Not set on both connectors
- PlumbCheck showed no WARNs on the gully RFA

Evidence

Observation	**Finding**
Downstream pipe (outlet side)	Section 2, Fixture Units = 0.000000
Section view	Gully visually connected — inlet above, outlet right — no gap visible
Upstream pipe (inlet side, fixture pipe)	Section 4, Fixture Units = 1.000000

FU = 1 arrived at the gully. FU = 0 left it. The gully showed Fitting | Not set — the connector configuration was correct. The break was not in the family; it was in the model.

The Counterintuitive Finding — Inlet, Not Outlet

The natural assumption, when the downstream pipe shows FU = 0, is that the **outlet connection** is broken. It is the outlet pipe that reads zero, so logically the fault should be there.

The actual break was on the **inlet side** — the pipe from the shower fixture to the gully inlet.

This is counterintuitive, but it follows directly from how Revit's MEP accumulation engine works:

The engine traverses the network from each fixture **downstream** toward the drain outlet. At each step it follows MEP connector references. If the inlet reference to a fitting is broken, the engine has no path into the fitting — the fitting never receives the FU. The outlet side then has nothing to pass downstream, so its connected pipe shows FU = 0.

The result: FU = 0 appears on the outlet pipe, but the fault is on the inlet pipe. Replacing the outlet pipe stub first will not fix the problem — the inlet stub is the one that must be redrawn.

In general, if you observe this pattern and are unsure which side is broken:

1. Redraw the inlet stub (fixture side) first
2. Check the outlet pipe — FU should now propagate

MEP Connector References vs Visual Geometry

Revit maintains two representations simultaneously.

Visual geometry — what you see in plan, section and 3D views. A pipe end that visually touches a fitting connector port appears connected. This is purely graphical.

MEP analytical network — a graph of connector references that the FU, flow and pressure calculations traverse. A pipe contributes to calculations only if a live connector reference exists between its end connector and the fitting's port connector.

These two representations can diverge. When they do, the visual model looks correct but the analytical calculation is wrong.

The most common cause in practice is a **family reload cycle**, particularly when combined with a category change:

1. Family is loaded into the project as Plumbing Fixtures, and pipes are connected
2. Category changed to Pipe Fittings via LoadFamily — Revit reconnects the geometry but may not fully re-establish the MEP connector references
3. Category changed again to Pipe Accessories via LoadFamily — same risk
4. End state: pipes visually resting against the fitting, MEP references broken on one or both sides

Each LoadFamily call rebuilds the family instance. Revit attempts to reconnect any existing pipe segments to the new instance, but this reconnection is not guaranteed — particularly when the family category changes between loads, which alters the connector model the family exposes to the project.

This is a known Revit behaviour. It was encountered in the same project during stormwater network traversal testing, where similar phantom connections showed in the traversal output.

The Fix

Delete and redraw the pipe stub connecting to the fitting on the affected side. Do not move or stretch the existing pipe — that does not rebuild the MEP connector reference.

Procedure:

1. Note the pipe size, slope and invert level of the stub before deleting
2. Delete the short pipe stub between the fixture and the fitting inlet (or between the fitting outlet and the next downstream element)
3. Draw a new pipe stub, snapping precisely to the fitting's connector port — the blue-dot snap confirms MEP registration
4. Select the redrawn pipe and check Fixture Units in Properties
5. FU should now show the expected accumulated value

If FU is still 0 on the downstream pipe, repeat for the outlet stub.

PlumbCheck cannot detect phantom MEP connections. PlumbCheck analyses the family RFA — connector configuration, discipline and system classification. It has no visibility into whether placed instances in the project hold live MEP references to adjacent pipes. The gully in this case study showed no WARNs, and that was correct — the family was properly configured. The problem was entirely in the model, not the family.

Detection at the model level requires scanning placed pipe segments and comparing Fixture Units across fittings. A sudden drop from FU > 0 to FU = 0 across a fitting that should be pass-through is the signature. This is the scope of the WCT-PlumbFlow model traversal engine, not PlumbCheck.

How to Identify Phantom Connections in a Model

Until automated detection is available, the manual method is as follows:

1. In a drainage plan view, click each pipe segment in a run and check Fixture Units in Properties
2. Trace the run from the fixture downstream toward the drain outlet
3. If FU drops from a positive value to 0 at a specific fitting, that fitting has a phantom connection on one or both sides
4. Note: the drop appears on the **outlet side** — but start your redraw on the **inlet side** first (see above)

Revit's built-in System Inspector can also be used: select a pipe, go to the Systems tab, and use the system highlighting to check whether downstream elements belong to the same MEP system. An element that appears disconnected from the system despite visual connection is a phantom.

Get it right prior to modelling the project

Test you RFAs for accumulation in a testing (sandbox) trial modelling environment that won't affect your primary model before commencing the project. Fixing RFA connectors mid project is hazardous (as outlined above) and results cannot always be guaranteed.

1.4 Open-Ended Pipes — Unconnected Pipe Stubs Silently Halt FU Accumulation

What Is an Open-Ended Pipe?

An open-ended pipe is a pipe segment that terminates without connecting to a fitting, fixture or cap. In Revit's graphical view, the pipe end appears as an open connector port — a small hollow square or circle at the pipe terminus. No warning is issued and no system error appears. The pipe is simply not part of a continuous MEP network path beyond that point.

This condition is common during the model build phase: a pipe is drawn toward its intended connection point but not yet snapped and registered to it. The visual gap may be zero — the pipe end can sit flush against a fitting body without the MEP connector reference being live.

Why It Stops Accumulation

Revit's FU accumulation engine traverses the MEP analytical network by following connector references. At each element, it reads the connected element on each connector port and continues downstream. At an open pipe end there is no connector reference — the traversal has nowhere to go. FU accumulated from upstream fixtures stops at that point and does not continue into the downstream network.

The symptom is identical to a phantom MEP connection (Section 1.3): FU is present on the upstream pipe, FU is zero on the downstream pipe, and nothing in any Revit view flags the break. The distinction is in the cause:

Cause	Appearance in model	Cause of break
Phantom MEP connection (Section 1.3)	Pipe appears visually connected to fitting	MEP reference broken by reload cycle
Open-ended pipe (this section)	Pipe end sitting at or near a fitting port	MEP connection was never made

The fix procedure differs: phantom connections require the pipe stub to be redrawn; open-ended pipes require the pipe end to be properly snapped and registered to the target element.

How to Identify an Open-Ended Pipe

Manual method:

1. In a drainage plan view, select each pipe segment in a run and check Fixture Units in Properties
2. Trace the run from the fixture downstream — find the segment where FU drops to 0
3. Select the pipe immediately upstream of the drop and note which end has the open connector
4. Zoom in to that pipe end and check for an open connector indicator (hollow square/circle at the pipe terminus)
5. If present, the connection to the next element was never registered

Using the System Inspector:

Select the upstream pipe, go to the Systems tab, and use system highlighting. Any element that is visually adjacent but does not highlight as part of the same system is analytically disconnected. An open pipe end will show the highlight terminating at that segment.

The Fix

Snap the open pipe end to the target element's connector port:

1. Select the pipe
2. Drag the open end connector grip precisely to the fitting's connector port — a blue snap indicator confirms the MEP connection is live
3. Alternatively, delete the short pipe stub and redraw it, snapping precisely at both ends
4. After reconnection, select the downstream pipe and confirm Fixture Units shows the expected accumulated value

Do not rely on visual proximity — the pipe end must snap to the connector port, confirmed by the blue-dot indicator. A pipe that visually touches a fitting but was not snapped to it during the draw will remain analytically open.

The most common occurrence of open ends are Vent terminations and Inspection openings to surface

Cap your open ends such as Vents and Inspection openings to surface and leave the system termination point (last pipe downstream) open

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Chapter 2 — Stormwater (AS3500.3)

2.1 Stormwater in Revit — The System Type Anomaly

The Problem: Revit Has No Native Stormwater System Type

Revit's MEP pipe system classifications were designed for mechanical and hydraulic services. The available types relevant to plumbing are Sanitary (sewage), DomesticColdWater, DomesticHotWater, OtherPipe, and a handful of fire protection types. There is no "Stormwater" entry.

Autodesk's intended convention is to use **OtherPipe** for stormwater. This works if your stormwater fittings (bends, tees, junctions) are configured as OtherPipe or Fitting. GenericFitting (system classification 28) is the correct configuration for all DWV fittings — see Section 1.1 — because it allows the same physical fitting family to serve both sewer and stormwater without modification.

Why Some Projects Use Sanitary for Stormwater Pipes

In practice, the pipe system type you assign to stormwater pipes depends on which Revit pipe type template you select when routing. If your project template was set up with stormwater pipes routed as the Sanitary system type, the physical DWV fittings (bends, junctions, reducers) will connect correctly because they are Fitting and inherit from the pipe. The network functions normally.

The consequence is that **rainwater outlets (RWOs)** placed into that stormwater network must also have their connector system type set to **Sanitary** — otherwise Revit throws a system-type mismatch warning on placement. Revit will still complete the connection, but the warning it delivers does not identify the root cause (a mismatched connector system classification) and offers no obvious resolution path — making it a common source of confusion for drafters and BIM coordinators.

Note that this is not an error in the family authoring. It is a consequence of the project template's pipe routing convention: the RWO family is configured correctly for the project it was designed

How WCT-PlumbCheck Handles Both Conventions

PlumbCheck validates the outlet connector on all stormwater families against the following rule:

Connector system type	Linked parameter	PlumbCheck result
Sanitary	Fixture Units (WFU)	PASS — sewer fixture
Sanitary	LitresPerSecond	PASS — stormwater outlet in Sanitary-typed pipe network
OtherPipe	LitresPerSecond	PASS — stormwater outlet in OtherPipe-typed pipe network
Sanitary or OtherPipe	Neither linked	WARN — outlet has no flow data

Both the Sanitary and OtherPipe stormwater conventions are valid; PlumbCheck does not penalise either. What matters is that the outlet connector carries a LitresPerSecond parameter linked to a family parameter — this is the data the WCT-PlumbFlow traversal engine reads to accumulate network flow.

Project Template Consistency

Whichever convention your project template uses, it must be applied consistently:

- **All stormwater pipes** in the template should use the same system type
- **All RWO families** loaded into that template must have their connector system type set to match
- **All DWV fittings** used in the stormwater network should remain Fitting (28) — this works correctly regardless of whether the pipe system type is Sanitary or OtherPipe

Mixing conventions within a project — some stormwater pipes as Sanitary, others as OtherPipe — will produce system-type mismatch warnings in Revit and unreliable network traversal results.

Summary

Item	WCT convention (Sanitary pipes)	Alternative (OtherPipe pipes)
Stormwater pipe system type	Sanitary	OtherPipe
DWV fitting system type	Fitting (28)	Fitting (28)
RWO connector system type	Sanitary	OtherPipe
RWO linked parameter	LitresPerSecond	LitresPerSecond
PlumbCheck result	PASS	PASS

The engineering data is identical in both conventions. Only the Revit system classification label differs.

WCT-PlumbFlow — An example of Stormwater Network Traversal (Available separately)

Workflow

WCT-PlumbFlow operates as a two-button tool. Click the ribbon button to open the dialog.

Select network pipe for flow analysis

Click this button, then click any pipe in the stormwater network in the Revit model. The tool automatically:

1. Assigns sequential marks (RWO-01, RWO-02 ...) to all rainwater outlets in the model, sorted by level elevation (low to high), then left to right, front to back
2. Traverses the connected pipe network upstream from the selected pipe, accumulating flow from every rainwater outlet it reaches
3. Places blue flow labels in the active view at every RWO location and every junction where accumulated flow increases
4. Highlights any pipe junctions where the network is broken (see *Network Integrity Checking* below)

The dialog closes automatically when the analysis completes. The drafter then has a fully annotated stormwater network visible in the model — no further action required until a change is made.

Clear Markers

Removes all flow labels and network break indicators placed by the previous run. This button is greyed out when no markers are present. After clearing, the drafter can immediately re-run by clicking the ribbon button again and selecting a pipe.

Note: markers can also be removed using Revit's standard Ctrl+Z (Undo). If markers are undone, the Clear

Terminology

Rainwater Outlet (RWO)

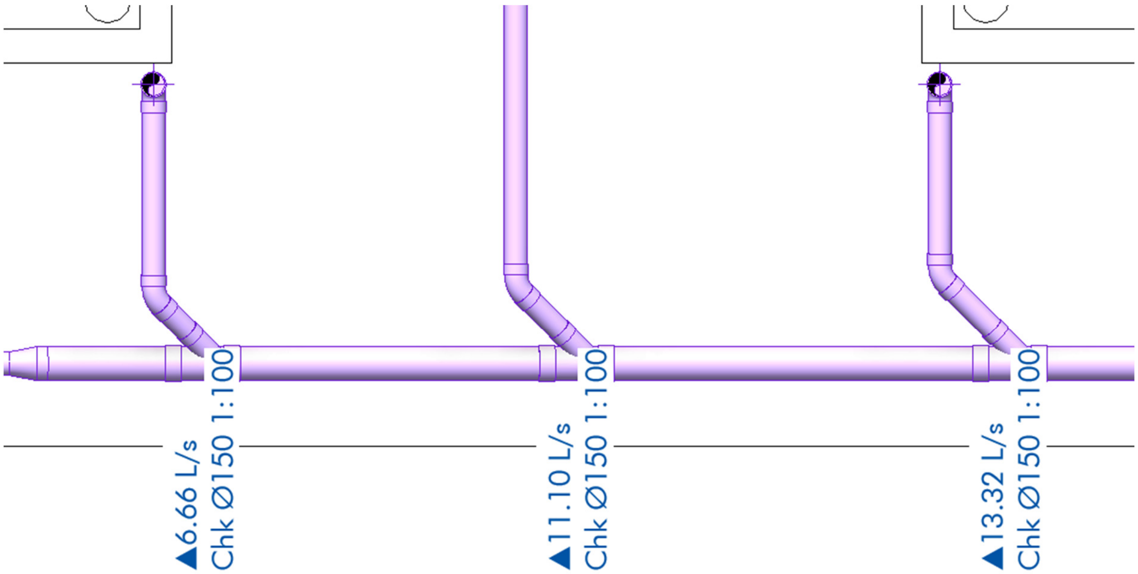
A rainwater outlet is any Revit family that carries a LitresPerSecond shared parameter with a value greater than zero. This is the only criterion — the family name, description and category are irrelevant to the tool. The LitresPerSecond value represents the design stormwater flow rate for that outlet's roof catchment under the design rainfall event, calculated externally using the rational method (AS3500.3) and stored on the family instance.

The tool assigns sequential marks to all RWOs found in the model each time an analysis is run. Marks take the form **RWO-01, RWO-02 ...** and are written to the standard Revit **Mark** parameter, making them immediately schedulable and taggable without any additional configuration.

Individual RWO Flow Label

A blue label showing the design flow of a single rainwater outlet, placed at the RWO's location in the model. Format: **7.00 L/s**

This label reports the LitresPerSecond value stored on that specific RWO family — the flow from that outlet's catchment alone. It confirms which outlets the tool has found and lets the drafter verify flow values against the stormwater calculation.



Resulting annotation tags after running the PlumbFlow Stormwater Traversal Tool

Accumulated Junction Flow Label (▲)

A blue label placed at each pipe junction (tee fitting) where the accumulated upstream flow increases. Format: **▲18.00 L/s**

The **▲ symbol** acts as an arrowhead pointing to the junction — it indicates the total flow at this point in the network, downstream of all the contributing outlets above. The label is positioned just outside the pipe wall at the branch entry point and rotated to read along the branch stub direction, making it clear which junction it refers to and how much flow is entering the collector at that point.

The accumulated flow at any junction is the sum of LitresPerSecond from every RWO that drains to that point through the connected pipe network. This is the number that governs the required pipe size at that location.

Example: a collector with three branch stubs, each carrying a 7.00 L/s outlet, will show ▲7.00 at the first junction, ▲14.00 at the second, and ▲21.00 at the third — stepping up as each branch enters.

Sequential RWO Marks (RWO-01, RWO-02 ...)

Sequential marks are written to the Revit **Mark** parameter on each RWO family instance. They are assigned by level (lowest floor first), then left to right, front to back within each level. The marks provide a consistent reference number for each outlet, which:

- Appears in the Revit schedule alongside the outlet's family name and LitresPerSecond value
- Can be tagged in plan, section or elevation views using a standard Revit tag family
- Provides a stable label for cross-referencing between the model and an external stormwater calculation

Marks are re-assigned every time a new analysis is run, so adding or removing outlets does not require manual renumbering.

Directional Traversal — How Upstream Is Determined

The traversal detects flow direction using pipe connector elevations. Stormwater pipes slope downward toward the outfall — the upstream end of any pipe is higher than its downstream end. When a pipe with a measurable fall is selected, the tool starts from the upper connector only and refuses to walk back downhill as it explores the network.

Minimum detectable slope: any pipe segment with a fall of approximately 1.5 mm or more between its two ends will be correctly identified as directional. This covers:

Slope	Fall per 1 m	Fall per 0.3 m	Detectable?
1:50	20 mm	6 mm	Yes ✓
1:100	10 mm	3 mm	Yes ✓
1:200	5 mm	1.5 mm	Yes ✓

In practice, all pipe segments between fittings in a gravity stormwater system will exceed this threshold. The directional traversal is reliable for any AS3500.3-compliant gravity drainage installation.

Siphonic Drainage Systems — Scope Limitation

Siphonic roof drainage systems operate under full-bore pressurised flow conditions. The pipes are typically installed level, may rise and fall, and the system acts as a single hydraulic unit — the concept of "upstream" and "downstream" within the network does not apply in the same way as it does in gravity drainage.

WCT-PlumbFlow cannot perform directional traversal on a siphonic network because there is no elevation gradient to follow.

This is not a deficiency of the tool — it is a reflection of the physics. Siphonic systems are not governed by AS3500.3. They are engineered solutions designed under manufacturer-specific hydraulic software (such as Fullflow or Polypipe Terrain) that accounts for siphonic pressure conditions, pipe sizing and balancing. WCT-PlumbFlow does not attempt to replicate or validate specialist siphonic analysis.

Engineering Significance of the Traversal Result

When **Traverse from Selection** returns a result, it is reporting the probable simultaneous stormwater flow at the selected point in the network — the accumulated contribution of every rainwater outlet draining to that pipe under the design rainfall event.

This is the number that determines the required diameter of the downpipe or collector at that location. Different outlets contribute different flows — a large roof bay versus a small corner bay will carry different LitresPerSecond values. The traversal sums them correctly regardless of how many outlets are upstream, how they are distributed across the roof, or how many levels contribute to the downpipe.

For a multi-storey building, selecting the downpipe immediately below each level's branch connection gives the stepped accumulated flow that governs pipe sizing at each level. The downpipe must be sized for the flow it actually carries — which increases at each branch junction as additional catchments join. The traversal produces this stepped result automatically from the model, replacing a manual calculation that would otherwise require the engineer to identify and sum each contributing outlet by hand.

This is the core engineering value of WCT-PlumbFlow: the model knows the network topology, the families carry the flow data, and the tool assembles the calculation.

Pipe Sizing Recommendations — Manning's Formula

Each junction label displays a preliminary pipe size recommendation on the line below the accumulated flow:

▲14.00 L/s

150 (Check dia. suggested)

The recommendation is calculated using Manning's open-channel flow equation for a circular pipe:

$Q = (A / n) \times R^{(2/3)} \times S^{(1/2)}$

where:

- **Q** = flow (m^3/s)
- **A** = pipe cross-sectional area (m^2)
- **n** = Manning's roughness coefficient — **0.010** for smooth PVC bore (AS3500.3)
- **R** = hydraulic radius = D/4 for a full circular section
- **S** = pipe slope (m/m)

The full-bore capacity is calculated using the equation above, then derated to **75% of full-bore capacity** as the design limit — standard Australian hydraulic practice to maintain a free surface, accommodate sediment, and allow for surge. The tool steps through the AS3500.3 standard stormwater DN series — 100, 150, 225, 300, 375 mm — and returns the smallest DN whose 75% capacity meets or exceeds the accumulated flow at the actual pipe slope. If the flow exceeds the capacity of DN375, the label shows >DN375 — Civil scope, indicating the system is beyond hydraulic engineering scope and should be referred to a civil drainage engineer.

The slope used is the actual modelled slope of the outlet pipe at each junction, read directly from the pipe's connector elevations in Revit. This means the sizing recommendation automatically reflects the as-modelled fall — a steeper outlet pipe will require a smaller DN than the same flow on a shallower pipe.

Vertical Drops and Near-Vertical Sections

AS3500.3 defines a downpipe as a vertical or near-vertical pipe conveying stormwater from a roof catchment, with a maximum capacity of **16 L/s** per pipe. A vertical drainage section carrying more than 16 L/s is not a downpipe in the code sense — it is a **vertical section of the stormwater drainage system**, and it falls outside the scope of Manning's open-channel formula, which applies to gravity flow in inclined pipes.

Manning's formula gives unreliable results for near-vertical pipes. At a slope approaching 1:1, the equation suggests a very high capacity, which would produce an incorrectly small DN recommendation — potentially smaller than the horizontal drain it connects to, violating the AS3500.3 principle that drainage pipes must not diminish in size along the flow path.

WCT-PlumbFlow therefore suppresses the sizing recommendation for any pipe with a slope steeper than 1:2. The junction label shows the accumulated flow only:

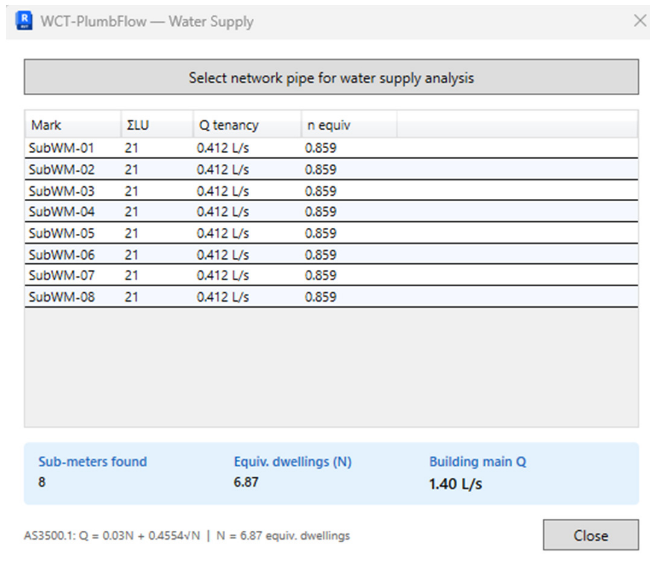
e.g. ▲88.00 L/s

The sizing of the vertical section is left to the engineer's judgement. Common approaches include:

- **Continuity of design —** size the vertical section to match the horizontal drain immediately downstream, so it cannot become the bottleneck.
- **Engineered solution —** where flows are large, a purpose-designed shaft, culvert or proprietary drainage product may be appropriate, and standard pipe sizing tables do not apply.

Manning's sizing recommendation resumes automatically on the next horizontal drainage run downstream of the vertical drop, where the formula is valid and the slope is meaningful.

Chapter 3 — Hot and Cold Water Supply (AS3500.1)



The PlumbFlow plugin's Water Supply analysis dialog box for 8 Typical apartments each with 21 Loading Units

3.1 Loading Units — The Foundation of Water Supply Sizing

What Is a Loading Unit?

A **loading unit (LU)** is a dimensionless number assigned to each plumbing fixture that represents its relative demand on the water supply system. The concept comes from probability theory: multiple fixtures in a building will not all operate simultaneously, so the probable simultaneous demand is lower than the sum of individual flow rates. Loading units allow this diversity to be quantified.

AS3500.1 defines loading units in **Table 3.2.1**. Each fixture type has a fixed LU value based on its typical flow rate and frequency of use.

AS3500.1 Table 3.2.1 — Loading Units

Fixture	Cold Water LU	Hot Water LU
WC cistern	2	—
Basin (standard tap)	1	1
Basin (spray tap)	0.5	0.5
Shower	2	2
Bath	8	8
Kitchen sink (standard)	3	3
Kitchen sink (aerated)	1.5	1.5

Fixture	Cold Water LU	Hot Water LU
Laundry trough	3	3
Washing machine	3	—
Hose tap (15mm)	3	—
Hose tap (20mm)	5	—
Hot water unit (CW inlet)	8	—

Notes: WC cisterns are cold water only. Washing machines and hose taps are cold water only. Hot water units carry LU on their cold-water inlet only — they are heat sources, not demand fixtures.

How Revit Stores Loading Units

Revit has no native AS3500.1 loading unit field. WCT-PlumbFlow & PlumbCheck (Available Separately) uses **shared parameters** stored on the connector element inside each family:

- CWLU — Cold Water Loading Units (integer)
- HWLU — Hot Water Loading Units (integer)

These parameters are linked to the connector's **Fixture Units** property using a Revit formula (= CWLU). The connector's **Flow Configuration** must also be set to **Fixture Units** (not Calculated). Both conditions must be met — this is the mechanism that causes Revit to accumulate LU values through the pipe network, so that every pipe segment upstream of a fixture picks up that fixture's LU contribution.

The result appears in the pipe's **Fixture Units** property (visible in the Properties panel). This is the value WCT-PlumbCheck reads for sizing calculations.

Critical: the CWLU/HWLU parameters must be linked to the connector via a formula (the = sign), not entered as a direct value. A direct value will not accumulate through the network.

3.2 Fixture-Connection Valves vs Isolation Valves — A Non-Obvious Principle

This is one of the most commonly misunderstood aspects of water supply BIM in Australian practice, and it is not documented elsewhere.

The Rule

A fixture-connection valve carries the hydraulic identity of the fixture it serves.

A fixture-connection valve is a valve placed immediately at the fixture to isolate only that fixture — an angle stop under a basin, a cistern valve on a WC, a stop cock at a washing machine. In hydraulic terms, this valve is part of the fixture assembly. It does not add demand; it is the point where that fixture's LU enters the system.

Classify as: Pipe Accessories
Assign: the same LU as the fixture it serves

An upstream isolation valve carries no load of its own.

A zone valve, branch valve or riser isolation valve serves multiple fixtures. It is a flow control device, not a demand source. It has no LU of its own.

Classify as: Pipe Accessories
LU: zero (no CWLU/HWLU parameters required)

Important note

Revit's LU accumulation engine works by summing the Flow values on all connectors in a connected pipe system.

If an isolation valve is placed in Plumbing Fixtures and accidentally picks up LU data from a Description match, it will inject phantom demand into the network.

A hose tap (classified as Pipe Accessories) and an inline isolation valve (also classified as Pipe Accessories) are handled differently by design as one delivers Loading Units and the other passes them through.

3.3 Pumps, Water Heaters and Hot Water Units

Category

Pumps, water heaters and hot water units must be placed in the **Plumbing Equipment** category in Revit. By definition they are in line appliances that are connected to a power source

For example a hot water unit is not a plumbing fixture — it does not consume water at a fixture outlet. It is a heat-producing appliance that transforms cold water into hot water and passes it through to the hot water distribution system. Its connector topology reflects this:

- **Cold water inlet** — DomesticColdWater, In
- **Hot water outlet** — DomesticHotWater, Out

This In/Out topology across two different system types is unique to heat-producing appliances.

Important delineation: the 8 LU value from AS3500.1 Table 3.2.1 applies specifically to a **domestic hot water unit serving a single dwelling**. A centralised hot water system serving multiple dwellings, or any commercial hot water plant, falls outside this rule and requires a different sizing methodology. The WCT sample model and this configuration guide are scoped to the single-dwelling case.

A water heater sits at the boundary of two separate pipe networks, and its role is different in each:

- On the **cold water network**, it is the **last fixture** — it draws cold water in and must be sized for. AS3500.1 Table 3.2.1 assigns it **8 LU** on the CW inlet. This demand accumulates back through the CW pipes to the cold water main, exactly as a basin or shower would.
- On the **hot water network**, it is the **first pipe** — a supply source. All HWLU values come from the individual fixture connectors downstream (each basin contributes 1 HWLU, each shower 2 HWLU, and so on). Those accumulate back through the HW distribution pipes to the water heater outlet naturally. The outlet itself carries no LU.

This is why the two connectors are configured asymmetrically: the CW inlet injects demand, while the HW outlet simply provides a network origin point. The two networks are completely independent — do not attempt to bridge them or pass HW fixture demand through to the CW side.

Configuring the CW Inlet Connector

The CW inlet requires a CWLU shared parameter to be created, added to the family, and linked to the connector's Fixture Units property. This is a one-time setup per parameter file.

Step 1 — Create the shared parameter file (once only):

- Manage tab → **Shared Parameters**
- Click **Create** → navigate to a shared folder → save as e.g. WCT_Hydraulic_Parameters.txt
- Groups → **New** → name it Hydraulic - Water Supply → OK

Step 2 — Add CWLU to the file:

- Parameters → **New**
- Name: CWLU, Discipline: **Common**, Type of Parameter: **Number** → OK
- Close the Shared Parameters dialog

Step 3 — Add CWLU to the family:

- Create tab → **Family Types** → **Add Parameter**

- Select **Shared parameter** → click Select → browse to your file → choose CWLU → OK
- Set scope to **Type** → OK
- In Family Types, set CWLU = **8**

Step 4 — Link the connector Fixture Units to CWLU:

- Select the **CW inlet connector** in the drawing area
- In the Properties panel, find **Fixture Units**
- Click the small grey **=** button to the right of the value
- In the "Associate Family Parameter" dialog, select **CWLU** → OK

The connector's Fixture Units is now driven by CWLU. WCT-PlumbCheck will read fixtureUnitsLinkedTo = "CWLU" and pass.

Configuring the HW Outlet Connector

The HW outlet is a supply source — no LU parameter is required. Configure the connector as follows:

- System Classification → **DomesticHotWater**
- Flow Direction → **Out**
- Flow Configuration → **Calculated**

Do not add an HWLU parameter or link Fixture Units on this connector. The hot water distribution network accumulates HWLU from the downstream fixture connectors, not from the water heater outlet.

Common Fault

Water heater families are often built in the Pipe Accessories template because they connect inline to a pipe run. This is incorrect. The consequence is that the CW inlet LU is either missing or cannot be validated, and the family will not accumulate correctly in the model's water supply system totals.

3.4 Why Revit's "Flow" Property Is Wrong for Australian Practice — and What to Use Instead

If you open the properties of a domestic cold water pipe in a Revit model with plumbing fixtures connected, you will see two calculated values:

- **Fixture Units** — the sum of loading units from all connected fixtures upstream
- **Flow** — a flow rate in L/s derived from those fixture units

The Fixture Units value is correct. The Flow value is not.

The Root Cause

Revit was developed in the United States. Its pipe flow engine uses the **International Plumbing Code (IPC)**, which is based on **Hunter's Curve** — an empirical method developed by Roy Hunter in the 1940s for American plumbing systems.

Hunter's formula converts fixture units to probable simultaneous flow using:

$Q \approx 0.315 \times \sqrt{(\Sigma FU)}$

The Australian standard **AS3500.1** uses a different formula, derived from different assumptions about simultaneous demand in Australian buildings:

$PSFR \approx 0.09 \times \sqrt{(\Sigma LU)}$

The ratio between the two coefficients is **3.5**. This means Revit's Flow property overstates probable simultaneous demand by a factor of roughly 3.5 for Australian buildings.

Practical example: 5 basins and 1 shower = 7 loading units (AS3500.1).

	Value
Revit Flow property	1.25 L/s
Correct AS3500.1 PSFR	0.24 L/s
Ratio	5.2×

If you sized a pipe based on the Revit Flow property, you would select a pipe approximately two nominal diameter sizes larger than required by the Australian standard — a material and cost overrun with no hydraulic benefit.

Can Revit's Flow Engine Be Changed?

Revit provides a developer interface (IPipePlumbingFixtureFlowServer) that theoretically allows the FU→Flow conversion to be overridden with a custom formula. In practice, this interface has been documented as unreliable since Revit 2017 and was never fully delivered by Autodesk. It cannot be depended upon across Revit versions, and is not a viable path for production tooling.

More fundamentally, the problem is not worth solving at the Revit engine level. The Flow property is an internal Revit calculation result displayed in the Properties panel; it is not the appropriate format for a hydraulic calculation deliverable. What the engineer and certifier need is the calculated PSFR, the required pipe nominal diameter, and a pass/fail status — not a number buried in Revit's Properties panel.

The "Divide by 3.5" Workaround (not recommended)

Some practitioners have proposed storing LU values divided by 3.5 in the Revit Fixture Units field, so that when Revit applies Hunter's formula, the resulting Flow approximates the AS3500.1 PSFR.

This approach is not recommended. The 3.5 ratio is only an approximation that converges at large fixture counts. At 7 LU, the actual ratio between the two methods is 5.2×, not 3.5×. The workaround also corrupts the LU data stored in the model — the Fixture Units value no longer represents actual AS3500.1 loading units, making it unusable for any other purpose, including scheduling and audit.

The Correct Approach

Ignore the Revit Flow property entirely.

WCT-PlumbCheck reads the **Fixture Units** property — which Revit accumulates correctly — and applies the AS3500.1 Table 3.2.4 formula independently:

PSFR = 0.09 × √(Fixture Units)

The results are written back to the model as pipe shared parameters:

Parameter	Content
CWLU_PSFR	Calculated probable simultaneous flow rate (L/s)
DN_Required	Minimum required nominal diameter per AS3500.1
HydraulicStatus	PASS / WARN

These parameters are schedulable. The hydraulic calculation schedule is the deliverable — not the Revit Flow property.

Summary Rule

Fixture Units = correct. Use it.
Flow = **US standard, wrong for Australia. Ignore it.**
WCT-PlumbFlow bridges the gap — reads the correct data, applies AS3500.1, writes the result.

3.5 AS3500.1 Pipe Sizing — The Two-Tier Framework

Overview

AS3500.1 uses a two-tier approach to pipe sizing that accounts for the statistical behaviour of simultaneous demand at two scales: within a tenancy, and across a whole building.

Understanding *why* two tiers are needed — not just how to apply them — matters for anyone implementing or auditing an automated sizing tool.

Tier 1 — Within Tenancy (Branch Sizing)

AS3500.1 Table 3.2.4 — Probable Simultaneous Flow Rates (PSFRs)

For a tenancy (apartment, retail shop, office floor), sum all fixture loading units and read the PSFR from Table 3.2.4.

The underlying formula for Table 3.2.4 is:

$$PSFR \approx 0.09 \times \sqrt{(\Sigma LU)}$$

This formula covers 1–60 LU — the full range of virtually all individual tenancies. It can also be used to extend Table 3.2.4 beyond 60 LU when required.

Verification: 30 LU → 0.09 × $\sqrt{30}$ = 0.493 ≈ 0.47 L/s. AS3500.1 Table 3.2.4 at 30 LU = 0.47 L/s. ✓

The Bridge — 0.48 L/s per Dwelling

The two tiers are connected by a calibration point: **1 standard Australian dwelling = 0.48 L/s**.

This comes directly from AS3500.1 Table 3.2.3, which sets the flow rate for a single dwelling at 0.48 L/s. Table 3.2.4 at 30–31 LU = 0.47–0.48 L/s. Therefore:

A standard Australian dwelling ≈ 30 LU

The fixture content that produces ~30 LU for a typical Australian home:

Fixture	LU
1 × WC cistern	2
1 × Basin	1
1 × Shower	2
1 × Bath	8
1 × Kitchen sink	3
1 × Laundry trough	3
1 × Washing machine	3
1 × Hot water unit (CW)	8
Total	**30 LU → 0.47 L/s**

The exchange rate: PSFR (L/s) ÷ 0.48 = equivalent dwelling count (n)

This works for any tenancy type — residential, retail, café, mixed-use — because L/s is the common currency. The tool never needs to categorise tenancy type; it reads the PSFR at the sub-meter.

Tier 2 — Building Main Sizing

AS3500.1 Table 3.2.3 — Probable Simultaneous Demand (PSD)

For the building main, convert each tenancy's PSFR to equivalent dwellings and sum them, then apply the formula from AS3500.1 Note 2 below Table 3.2.3:

$$Q = 0.03n + 0.4554\sqrt{n}$$

where:

- Q = flow rate (L/s)
- n = number of equivalent dwellings

This formula has no upper limit; it scales to any building size.

Verification against Table 3.2.3:

- n=1: 0.03 + 0.455 = **0.48** ✓
- n=10: 0.30 + 1.440 = **1.74** ✓
- n=50: 1.50 + 3.220 = **4.72** ✓

The table *is* the formula. Once you have the formula, you no longer need the table.

The Complete Architecture

Each tenancy:

$\Sigma LU \rightarrow PSFR = 0.09 \times \sqrt{\Sigma LU} \rightarrow PSFR$ (L/s)

↓

$PSFR \div 0.48 = n$ equivalent dwellings

Building main:

$\Sigma n_{equiv} \rightarrow Q = 0.03n + 0.4554\sqrt{n} \rightarrow PSD$ (L/s)

↓

Main pipe DN selection

Key properties of this framework:

- No table lookups required — both tiers are fully formulaic
- No special cases for mixed-use — the L/s common currency handles all tenancy types
- No upper limit on building size — the formula scales indefinitely
- Fully defined by AS3500.1 — no extrapolation or engineering judgement required in the algorithm

Why Two Tiers Are Mathematically Necessary

The sub-meter boundary is not merely administrative — it is mathematically load-bearing.

Because the square root function is concave (√ grows more slowly than linearly), the sum of square roots is always greater than the square root of the sum:

$\Sigma\sqrt{LU_i} > \sqrt{\Sigma LU_i}$

Treating all LU in a building as a single pool therefore underestimates demand compared with summing PSFR per tenancy first.

Example: 10 apartments, each 30 LU

Method	Result
Two-tier (correct): 10 × PSFR(30 LU) → n=10 equiv → Q formula	**1.74 L/s**
Single pool (incorrect): PSFR(300 LU)	**1.56 L/s**

The single-pool approach under sizes the main by roughly 10%. The gap widens as the building grows. The sub-meter is the correct boundary between the two tiers.

Mixed Tenancy — The Crossover Formula

The two-tier framework applies equally to buildings with non-uniform tenancies — apartments alongside retail, cafés, restaurants or offices. The equivalent dwelling conversion handles this automatically:

n_equiv = (0.09 × √(ΣLU)) ÷ 0.48 = **0.1875 × √(ΣLU)**

Tenancy	ΣLU	Q (L/s)	n_equiv
1-bed apartment	18	0.38	0.80
2-bed apartment	30	0.49	1.02
Café	50	0.64	1.33
Restaurant	80	0.81	1.68

The tool never needs to categorise tenancy type. It reads ΣLU from the Revit pipe at each sub-meter, applies the crossover formula, and sums n_equiv for the building main. The formula handles all tenancy types uniformly.

Configuring the Sub-Meter RFA

A sub-meter is a **Pipe Accessory** built on the same principles as an isolation valve — it is inserted into the pipe run and requires no system-type matching on the connectors. One family, one type, works on any pipe system (CW or HW).

The meter contributes no loading units of its own. It is a transparent pass-through for Revit's native LU accumulation. PlumbFlow reads ΣLU from the pipe on the **In** connector side (the tenancy side) and applies the crossover formula for building main sizing.

Connector configuration:

Connector	Direction	Flow Config
Tenancy side	In	Calculated
Building main side	Out	Calculated

The In/Out direction is the only signal PlumbFlow needs to determine which side of the meter is the tenancy and which is the building main.

Required shared parameter:

Parameter	Type	Discipline	Group	Scope	Value
MAP_SubMeter	Yes/No	Common	Plumbing	Type	Yes

This must be a **shared parameter** (not a family parameter) so that it can appear in schedules and be exported to ODBC. PlumbSize identifies the element as a tenancy boundary by reading this parameter.

Set Description = **"Sub Water Meter"** and Type Mark = **"SUB-WM"** in Family Types. "WM" is reserved for Washing Machine in MAP practice abbreviations — the "SUB" prefix avoids that clash.

No CWLU or HWLU parameter is required — the meter adds no fixture loading units.

3.5a Most Disadvantaged Fixture (MDF) — Future Extension

After establishing Q_main and the sub-meter hydraulic ranking, the next design question is: **does the available mains pressure reach every fixture?** The most disadvantaged fixture (MDF) is not simply the highest or the furthest — it is whichever combination of elevation and pipe friction creates the greatest pressure demand at the connection point.

Governing Equation

P_connection ≥ P_static + P_friction + P_residual

P_static = 9.81 × ΔZ (kPa, where ΔZ = fixture elevation above connection in metres)

P_friction = Hazen-Williams(L_equiv, Q, d)

L_equiv = L_pipe × 1.5 (AS3500.1 allows 50% addition to straight pipe length to cover all fittings, valves, and meters — no individual fitting enumeration required)

P_residual = 150 kPa (AS3500.1 minimum operating pressure at fixture outlet)

Implementation Readiness

PlumbFlow already accumulates L_pipe (straight pipe length from the connection point to each element) during the BFS traversal. Fixture connector elevations are available from Revit XYZ coordinates. The 1.5× multiplier is a one-line change, and the Hazen-Williams pressure loss formula is the same shape as the Manning's stormwater work already in the project. This extension has been achievable without architectural changes to the traversal engine.

3.6 Schedule as Deliverable — The External Handoff Model

The Problem with Revit's Flow Property as a Deliverable

When an external consultant — a structural engineer, certifier or cost planner — receives a Revit model, they may open a pipe's properties and see a Flow value. That value is wrong for

Australian practice (see Section 3.4), and there is no practical way to fix it at the Revit engine level.

The Solution — Write the Calculation to the Model

Write AS3500.1 sizing results back to the model as pipe shared parameters. Any recipient of the model can schedule these parameters directly from Revit.

The hydraulic calculation schedule becomes the deliverable — a schedulable table showing every pipe branch, its accumulated LU, the calculated PSFR, the required DN, and pass/fail status. This is analogous to a structural engineer's reinforcement schedule embedded in the model.

This guide documents the methodology; you can then apply this theory to schedule the accumulated data as a document within the model.

Together they can constitute a complete, auditable hydraulic calculation set.

Educational Purpose & Disclaimer

WCT-PlumbCheck and WCT-PlumbFlow are reference implementations demonstrating how hydraulic engineering workflows can be embedded within a Revit BIM environment using AS3500 as the governing standard.

These tools are provided for educational and demonstrative purposes only, therefore do not constitute a design deliverable and must not be relied upon as a substitute for the independent judgement of a suitably qualified hydraulic engineer.

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