ILEMBE WATER & SEWER INFRASTRUCTURE INFORMATION PROJECT
VUTHELA CONTRACT VILP/I/041

Spatial and Attribute Information Management: Standard Operating Procedure (SOP) V1.0
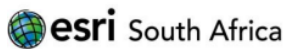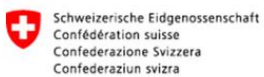
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Abbreviations:

FAR – Fixed asset Register

GIS – Geographic Information Systems

IDM – iLembe District Municipality

PMU – Project Management Unit

SOP – Standard Operating Procedure/s

Compiled by: ESRI South Africa

1 Purpose

This Standard Operating Procedure (SOP) for Geographic Information System (GIS) water and sanitation infrastructure and related data collection and management has been prepared to provide technical guidance for the collection and management of field data for the iLembe Water and Sewer Infrastructure Information Project, Vuthela Contract VILP/I/041. The aim of this document is to ensure that technical crews and contracted service providers apply a consistent methodology to allow for accurate collection of field data in a format that is standardized across the GIS platform and for use in different municipal departments (GIS, Technical Services, Asset Management). Additionally, it sets the standard for the supply of digital spatial data to the iLembe District Municipality (IDM) by external service providers and/or contractors for incorporation into the IDM's corporate GIS.

Furthermore, once the IDM has procured and established an integrated Asset Information Management System (AMIS), this SOP will further guide the information management and exchange inter-departmental and with external parties. It may however be that the SOP will need to be reviewed to ensure alignment with the AMIS.

1.1 Background

iLembe District Municipality (IDM) has chosen ESRI®'s ArcGIS (ArcGIS Pro or ArcMap) as its corporate GIS product. This document has been formulated to ensure that work carried out for the municipality is delivered in a format and to a standard that is acceptable to the GIS requirements of the organization. Due to staff and budget constraints, the exercise of conversion, "cleaning" and correcting of data by the municipal staff must be eliminated. Consultants are required to deliver fully correct GIS data in accordance with the guidelines set out in this document.

It is further expected that this document sets the initial standards for information management, sharing and maintenance within the organisation, with due cognisance of the different inter-departmental communications required.

1.2 Objectives

The Objectives of this SOP is to provide a guideline for:

1. Background/Objectives for the project

2. Detailed Data Structure breakdown:

   2.1 Geodatabase: Water & Sewer datsets

   2.2 Feature Classes, Subtypes & Domains

2   Data Structure

This section provides stakeholders with a common, standardized data structure that has been designed to enable efficient and accurate data capture and management. Standard naming conventions and directory structures foster easier collaboration between stakeholders and contractors. The datasets have been designed in such a way as to allow for integration of the department's Fixed Asset Register (FAR) attributes within the data structure.

A review of the data structure should be conducted once every 6 months by the iLembe GIS department, to ensure the structure remains updated.

2.1   Geodatabase

For the purpose of this project, a Geodatabase has been built, housing both **SEWER** and **WATER** data respectively. This data is inclusive of the original Feature Class tables (with the prefix FC) and the related tables created from the FAR (with the prefix RC).

Spatial Integrity: On 1st January 1999 South Africa officially changed its coordinate system to the WGS84 ellipsoid using the Hartebeesthoek '94 datum. Prior to this, the Cape Datum was used based on a modified Clarke 1880 ellipsoid. Most GIS data providers have now migrated their data to the new coordinate system, and it is crucial that all spatial data conforms to this coordinate system.

Diagram 1 below illustrates the contents of the Geodatabase.

GISDB_May_June_2023.gdb
- FC01_ReservoirZones_Table
- FC02_ReservoirZones_Table
- FC03_SewerPipes_Table
- FC04_SewerPumpStations_Table
- FC05_Sewer_Manholes_Table
- FC06_Sewer_TreatmentWorks_Table
- FC07_Umgeni_OperatedPipelines_Table
- FC09_Umgeni_PumpStations_Table
- FC10_Water_PlasticTanks_Table
- FC11_Water_PumpStations_Table
- FC12_WaterReservoirs_Table
- FC13_WaterAbstration_Table
- FC14_WaterReticulation_Table
- FC15_Water_TreatmentWorks_Table
- RC_Sewer_Outfall
- RC_Sewer_PumpStations
- RC_Sewer_WWTW
- RC_Water_AbstractionWorks
- RC_Water_Boreholes
- RC_Water_Bulk_Mains
- RC_Water_Plastic_Tanks
- RC_Water_Pump_Stations
- RC_Water_Reservoirs
- RC_Water_Reticulation
- RC_Water_WTW
- Readme_Sewer_Table
- Readme_Water_Table

- Sewer_BulkSewerLine
- Sewer_BulkSewerLineScreen
- Sewer_DischargePoint
- Sewer_Manhole
- Sewer_MonitoringPoint
- Sewer_OutfallSewer
- Sewer_ReticulationSewerLine
- Sewer_VIPs
- Sewer_WastewaterTreatmentWorks
- Sewer_WIP
- SewerPumpStation
- StudyArea
- Water_AbstractionWorks
- Water_Borehole
- Water_BreakPressureTank
- Water_BulkMeter
- Water_BulkWaterPipeline
- Water_Canal
- Water_ConsumerConnection
- Water_Dam
- Water_MonitoringPoint
- Water_PlasticTank
- Water_PumpStation
- Water_Reservoir
- Water_ReservoirZones
- Water_Reticulation
- Water_Spring
- Water_StandPipes
- Water_TreatmentWorks
- Water_ValveChamber
- Water_Weir
- Water_WIP

Diagram 1: The custom designed Geodatabase, showing the layout of the feature classes and tables within the geodatabase.

2.2   Feature Classes, Subtypes & Domains

Within the Geodatabase, data has been captured as individual feature classes. Each of these feature classes may also have certain subtypes and domains applied to their schema, to allow for efficient and accurate data capture.

2.2.1 SEWER - Subtypes

A detailed breakdown of the SEWER subtypes is provided in **Table 1** below.

SEWER Dataset		
Subtype Name	**Type**	**Subtype/s**
BulkSewerLineMaterial	Line	[HDPE; uPVC; oPVC; mPVC; Reinforced Precast Concrete; GRP; No_data]
BulkSewerLineScreen	Point	[BulkSewerLineScreen]
DischargePoint	Point	[DischargePoint]
OutfallSewer	Point	[Conventional; Packaged; No_data]
ReticulationSewerLineMaterial	Line	[HDPE; uPVC; oPVC; mPVC; Polypropylene No_data]
SewerManholeType	Point	[Masonry; Reinforced Concrete; No_data]
SewerMonitoringPoint	Point	[Monitoring Point]
SewerPumpStationType	Point	[Primary; Booster; No_data]
SewerWasteTreatmentWork	Polygon	[Conventional; Packaged; No_data]
SewerWIPType	Polygon	[CAPEX Project; OPEX Project; No_data]
VIPsType	Point	[Masonry; Reinforced Concrete; Corrugated Iron; Plastic; No_data]

Table 1: SEWER Dataset structure –Subtypes.

2.2.2   WATER - Subtypes

A detailed breakdown of the WATER subtypes is provided in **Table 2** below.

WATER Dataset

Subtype Name	Type	Subtype/s
BoreholeType	Point	[Borehole]
ConsumerConnectionType	Point	[Residential; Commercial; Industrial; Agricultural; No_data]
MaterialBulkWater	Line	[HDPE; uPVC; oPVC; mPVC; Reinforced Precast Concrete; Ductile Iron; GRP; Steel – SANS 719 Grade B; Steel – SANS 1431 Grade 300 AW and 350 AW; Steel – API 5L Grade X42, X46, X52, X56 and X60; No_data]
WaterAbstractionWorksType	Point	[RiverIntake; DamIntake; No_data]
WaterBreakPressureTankType	Point	[Concrete; Steel; No_data]
WaterBulkMeterPtMaterial	Point	[HDPE; uPVC; oPVC; mPVC; No_data]
WaterCanalType	Point	[Half Circle; Trapezoidal; V-drain; No_data]
WaterDamType	Polygon	[Earth; Concrete; No_data]
WaterMonitoringPointType	Point	[FlowGauge; Level Meter; Pigging Station; Pressure Gauge; No_data]
WaterPlasticTankType	Point	[JoJo; Roto; SBS; No_data]
WaterPumpStationType	Point	[Primary; Booster; No_data]
WaterReservoirType	Point	[Concrete-Ground; Concrete-Underground; SteelTower; SteelTank; No_data]
WaterReticulation	Line	[HDPE; uPVC; oPVC; mPVC; Reinforced Precast Concrete; Ductile Iron; Steel – SANS 62; Polypropylene; No_data]
WaterReticulationMaterial	Line	[HDPE; uPVC; oPVC; mPVC; Ductile Iron; Steel – SANS 62; Polypropylene; No_data]
WaterSpringType	Point	[Spring]
WaterStandPipesType	Point	[Standpipe]
WaterTreatmentWorksType	Polygon	[Conventional; Desalination; Package; No_data]
WaterValveChamberType	Point	[Air Valve Chamber; Isolating Valve Chamber; PRV Chamber; Scour Valve Chamber; Water Meter Chamber; No_data]
WaterWeirType	Point	[Weir]
WaterWIPType	Polygon	[CAPEX Project; OPEX Project; No_data]

Table 2: WATER Dataset structure – Subtypes.

2.2.3   Domains

Feature classes within the geodatabase may have certain subtypes and domains applied to them. This allows for the ease of data capturing and editing, as well as reducing the amount of incorrectly captured data. Some domains are specific to either the water or sewer theme, whereas others are applied across the data. A summary of all these domains is provided in **Table 3** below.

(**Note:** All diameters in the datasets refer to the outside diameter of pipes).

UNIVERSAL DOMAINS		
Description	**Domain Name**	**Coded Values**
Asset Operator	All_AssetOperator	**Name: All_AssetOperator** **Key** — **Description** 1 — iLembe DM 2 — Siza Water 3 — Umgeni Water 4 — SAPPI -100 — No Data
Asset Owner	All_AssetOwner	**Name: All_AssetOwner** **Key** — **Description** 1 — iLembe DM 2 — Siza Water 3 — Umgeni Water 4 — SAPPI -100 — No Data
Data Confidence	All_DataConfidence	**Name: All_DataConfidence** **Key** — **Description** 1 — Low 2 — Medium 3 — High -100 — No Data
Data Editor	All_DataEditor	**Name: All_DataEditor** **Key** — **Description** 1 — Navendran Govender 2 — Rajan Munien 3 — ESRI South Africa -100 — No Data
File Format	All_FileFormat	**Name: All_FileFormat** **Key** — **Description** 1 — CAD File 2 — Excel File 3 — GDB 4 — KML 5 — PDF File 6 — Shape File 7 — Text File -100 — No Data
Data Type	All_DataType	**Name: All_DataType** **Key** — **Description** 1 — As-Built 2 — As-Designed 3 — Digitized

		4	Field Sketch	
		5	GPS/GNSS	
		-100	No Data	
District Municipality	All_DistrictMunicipality	**iLembe**		
Municipality	All_Municipality	**Name: All_Municipality**		
		Key	**Description**	
		1	KwaDukuza	
		2	Mandeni	
		3	Maphumulo	
		4	Ndwedwe	
		-100	No Data	
Province Name	All_ProvinceName	**Kwa-Zulu Natal**		
Spatial Accuracy	All_SpatialAccuracy	**Name: All_SpatialAccuracy**		
		Key	**Description**	
		1	High (0-1 meter)	
		2	Low (>5 meters)	
		3	Medium (1-5 meters)	
		-100	No Data	
Status	All_Status	**Name: All_Status**		
		Key	**Description**	
		1	Decommissioned	
		2	Approved	
		3	In Service	
		4	Out of Service	
		5	Proposed	
		6	Removed	
		7	Retired	
		8	To be retired	
		9	Under Construction	
		-100	No Data	
Subplace	All_Subplace	**Name: All_Subplace**		
		Key	**Description**	
		1	Alexia SP	
		2	Bondis Drift	
		3	Charlottedale	
		4	Chris Hani SP	
		5	Darnall	
		6	Ematadeni SP	
		7	Eradamishini SP	
		8	Ethafeni SP	
		9	Groutville SP	
		10	Harold Johnson Nature Reserve	
		11	KwaDukuza Urban	
		12	Lloyd SP	
		13	Malende SP	
		14	Mandini	
		15	Memory SP	
		16	Mnyomawini SP	
		17	New Grodt	
		18	Newark Sand Mine	
		19	Njekane SP	
		20	Nkunkwini SP	
		21	Ntabaningi SP	

		22	Ntsangwini SP
		23	Padianager
		24	Sundumbili
		25	Thembeni SP
		26	Tugela SP
		27	UCC Informal SP
		28	Added AOI
		-100	No Data

SEWER DATASET DOMAINS:

Description	Domain Name	Coded Values	

Description	Domain Name	Coded Values	
Pump Station Service Zone	Sewer_PumpStationServiceZone	**Name: Sewer_PumpStationServiceZone**	
		Key	Description
		1	Pump station zone 1
		2	Pump station zone 2
		3	Pump station zone 3
		-100	No data
Reticulation Diameter	Sewer_ReticulationDiameter	**Name: Sewer_ReticulationDiameter**	
		Key	Description
		1	180 mm
		2	200 mm
		3	225 mm
		4	250 mm
		5	280 mm
		-100	No data
Reticulation Type	Sewer_ReticulationType	**Name: Sewer_ReticulationType**	
		Key	Description
		1	Gravity
		2	Pump
		-100	No data
Sanitation Scheme	Sewer_SchemeName	**Name: Sewer_SchemeName**	
		Key	Description
		1	Darnall
		2	Glenhow
		3	Mandeni
		4	Melville
		5	Stanger
		6	Sundumbili
		7	Tugela
		-100	No data
VIP Size	Sewer_VIPSize	**Name: Sewer_VIPSize**	
		Key	Description
		1	Size 1
		2	Size 2
		3	No data

WATER DATASET DOMAINS:

Description	Domain Name	Coded Values	
Borehole Supply Zone	Water_BoreholeSupplyZone	**Name: Water_BoreholeSupplyZone**	
		Key	Description
		1	Borehole supply scheme
		-100	No data
Canal Lining	Water_CanalLining	**Name: Water_CanalLining**	
		Key	Description
		1	Concrete
		2	Earth

		3	Reno mattress	
		4	Stone pitched concrete	
		-100	No data	

Consumer Meter Type	Water_ConsumerMeterType	**Name: Water_ConsumerMeterType**	
		Key	**Description**
		1	Conventional
		2	Pre-paid
		-100	No data

Diameter Bulk Water Lines	Water_DiameterBulkWater_**###** (Water_DiameterBulkWater_HDPE)	**(Various sizes of pipes, dependent on Subtype selected). See Annexure A**
Diameter Water Reticulation	Water_DiameterWaterReticulation_**###** (Water_DiameterWaterReticulo_HDPE)	**(Various sizes of pipes, dependent on Subtype selected). See Annexure A**

Nature of WIP	Water_NatureOfWIP	**Name: Water_NatureOfWIP**	
		Key	**Description**
		1	Greenfields
		2	Refurbishment
		3	Renewal
		4	Upgrade
		-100	No data

Plastic Tank Supply Zone	Water_PlasticTankSupplyZone	**Name: Water_PlasticTankSupplyZone**	
		Key	**Description**
		1	Plastic Tank Zone 1
		2	Plastic Tank Zone 2
		3	Plastic Tank Zone 3
		-100	No data

Pressure Ratings	Water_PressureRatings	**Name: Water_PressureRatings**	
		Key	**Description**
		1	2 bar
		2	3 bar
		3	4 bar
		4	5 bar
		5	6 bar
		6	8 bar
		7	9 bar
		8	10 bar
		9	12 bar
		10	16 bar
		11	20 bar
		12	25 bar
		13	30 bar
		14	32 bar
		18	40 bar
		19	64 bar
		20	100 bar
		-100	No data

Pump Station Supply Zone	Water_PumpStationSupplyZone	**Name: Water_PumpStationSupplyZone**	
		Key	**Description**
		1	Pump station zone 1
		2	Pump station zone 2

		-100	No data		
Reservoir Supply Zone	Water_ReservoirSupplyZone	span **Name: Water_ReservoirSupplyZone**		

		Key	Description		
		1	Ashton		
		2	Bethany Farm		
		3	Blythedale West		
		4	Darnall		
		5	Darnall Sugar Mill		
		6	Dube Village		
		7	Engqumeni Reservoir		
		8	Etete		
		9	Even Grand		
		10	Fawsley Park		
		11	Fort Pearson		
		12	Groutville		
		13	Highview Reservoir and Elevated Tank		
		14	Hlomendlini Reservoir		
		15	Hyde Park		
		16	Kearsney		
		17	Lindelani		
		18	Lushaba		
		19	Manchester1		
		20	Manchester2		
		21	Manda Reservoir		
		22	Mandeni Reservoir		
		23	Mangeni		
		24	Masonconco Reservoir		
		25	Mgigimbi		
		26	Mpunzi Reservoir and Springbok Tower		
		27	Ndulindi Reservoir 1		
		28	Ndulindi Reservoir 2		
		29	New Guelderland		
		30	New Reservoir at Nyoni Housing Scheme		
		31	Nill Blue		
		32	Njekane		
		33	Nyoni Reservoir		
		34	Padianagar Reservoir 1 and 2		
		35	Reservoir A		
		36	Reservoir B		
		37	Reservoir C		
		38	Rocky Ridge		
		39	Saddle Ridge		
		40	Saunders		
		41	Shakaville		
		42	Sithole		
		43	Siyaphambili		
		44	Stanger Manor		
		45	Tinley		
		46	Umvoti		
		47	Umvoti Heights		
		48	Warrenton		
		-100	No data		

Supply Scheme	Water_SupplySchemeName	Name: Water_SupplySchemeName	

		Key	Description
		1	Darnall
		2	Hazelmere: Groutville Region
		3	Sundumbili
		4	Tugela
		5	Umvoti Water Scheme
		-100	No data

Treatment Works Name	Water_TreatmentWorksName	Name: Water_TreatmentWorksName	
		Key	Description
		1	Lamela Package Plant
		2	Mandeni Water Treatment Plant Pump Station
		3	Mandeni Water Treatment Works
		4	Ndulinde Water Supply Scheme Phase 1
		5	SAPPI Works
		6	Sundumbili Water Works
		7	Tugela Water Treatment Plant
		8	Umvoti Water Treatment Plant
		-100	No data

Water Intake Source Name (Abstraction Works)	Water_IntakeSourceName	Name: Water_IntakeSourceName	
		Key	Description
		1	Umvoti River
		2	Nonoti River
		3	Tugela River
		-100	No data

Water Quality (Raw)	Water_RawQualityClass	Name: Water_RawQualityClass	
		Key	Description
		1	Class 0
		2	Class 1
		3	Class 2
		4	Class 3
		5	Class 4
		-100	No data

Table 3: Sewer and Water Domains

3   Data Capture Protocols

This section discusses data format conventions, data backup and data sharing policy. It is recommended that data formats, data map transfer protocols, and back up policies be standardized.

Spatial data provided to iLembe District Municipality will only be accepted in Geographic coordinates (longitude and latitude in decimal degrees) on the Hartebeesthoek '94 datum. The co-ordinate system that the data is delivered on must be clearly marked on the media as well as in the metadata. Data is to be supplied on clearly labelled external hard drive or USB media regardless of whether it is e-mailed or not. The media must be labelled with:

a) Project contract number, a Brief description of the data and/or project,

b) The consultant who submitted it with contact details and

c) The date of submission.

The absolute spatial accuracy per dataset must be quoted in the metadata in meters. The accuracy of the data will obviously vary per dataset but must be commensurate with the purpose for which it was captured or supplied as well as the scale it was intended for use.

3.1   Data Format Conventions

Acceptable Data Formats include:

- Spatial data formats: .dwg or .dxf, shapefile, file geodatabase, personal geodatabase, or KML/KMZ (Preferred format is geodatabase).

- As built record in shapefile or CAD file format such as .dwg. This must be accompanied by the .pdf layout in both hard and soft copy, as well as an Excel table of reference coordinates/Setting Out Points (SOPs) used in the construction phase.

- Spatial and attribute data on USB/External storage in the above-mentioned format

- APRX or MXD Project file, a map package and with associated layer files

- When working with Excel spreadsheets remember that cell values linked to calculations will not be translated between .xls and .dbf. If there are values of consequence that are linked to a calculation, create a new field for the data values and perform a paste special (Values only) before converting to .dbf. Make sure that there are no spaces in the header row and worksheet tabs. (formatting requirements for .dbf headers etc..)

- The geodatabase now intakes .xlsx and has always accepted .CSV files.

- Tables posted for consumption of use outside of GIS should be in an MS Excel (.xls) or (.xlsx) format to avoid software compatibility warnings when opening the file.

3.2 Data Considerations and Verification – Roles and Responsibilities

The GIS Section has a central co-ordinating role in ensuring that the spatial information assets of IDM are maintained regularly. This involves data capture, data editing and data deletion, where these assets may be removed.

The responsibility of data maintenance lies with the individual business units within IDM. This is of key importance in ensuring that spatial data is well maintained. The GIS unit will provide data capture forms and a computer-based data capture system to assist with this process where required.

Table 4 below details the key responsibilities of the various departments in the IDM with regards to the spatial information asset management of the IDM:

Department Name	Key Responsibilities
Corporate GIS	Management of master spatial database; Verification of data formats received from External Service Providers and Technical Services
Technical Services – O&M	O&M request the SCM to generate an order for maintenance work on existing infrastructure when needed. Once approved, the O&M team conducts the groundwork to replace or fix the hardware.
Technical Services - PMU	PMU receives the terms of reference from the SCM before generating a tender document. PMU is responsible for managing existing projects.
Technical Services - IT	IT is responsible for ensuring the upkeep and maintenance of municipal hardware and software.
Finance - SCM	Inclusion of SOP document in all tenders relating to spatial information gathering
Finance - Asset Management	Asset Management is responsible for updating the FAR once the new GIS ID and infrastructure record is provided by Corporate GIS.

Table 4: Key responsibilities by Department

GIS staff evaluate all datasets based on the following factors to assess if they will adequately meet the needs of the department:

- Coordinate System and Datum Information: This can be in the form of a file that contains the coordinate system information for the vector data and a word file for images or other documentation associated with the dataset.

- Scale: The scale of the dataset should be conducive for use with other datasets and map imagery.

- Currency: The dataset should be the most current available from the data custodian. Old version of the data should not be used. However, there are instances when it is necessary to use old versions because the data have been requested but the more current data cannot be located.

- Attributes: Datasets should contain meaningful attributes that help to make the data more actionable for effective decision-making.

- Accuracy: Datasets should meet locally acceptable accuracy requirements for a particular use. Marginal datasets may be used if an appropriate disclaimer is included and visible on the output product or tool.

- Data Security: Limitations on the use and distribution of security sensitive, licensed, or proprietary data should be evaluated at the source of the data. Be sure to include information about the use of sensitive data in any transition briefings and/or materials.

- Authority: Datasets should be acquired from the data custodian. If datasets are collected using online searches, documentation of the provider is critical to avoid conflict should questions arise over the data authority. Always take time to verify the data provider and vet their information as possible before using.

3.3 Data Backup Policy

A backup policy should expect the worst, in order to be prepared for any eventuality. Fire, theft, lightning strikes and total machine failure do not occur often, but when they do it will never be at a good time.

A backup policy should be robust but also pragmatic. IDM's ICT has a backup policy and provisions for weekly and monthly backups for the GIS information servers, however backups in the GIS Section must be conducted as well:

- Vector data must be replicated on the GIS specialist workstation on at least a bi-weekly basis.

- A monthly backup must be made onto removable media and stored off-site.

- A full GIS backup, including all imagery, must be made every time the imagery changes or is added to and also stored off site or in a fire-proof safe on site.

- Compression of directories using WinZip is recommended in order to limit the number of USB/External hardrives requiring writing.

3.4   Data Sharing Policy

All spatial datasets in the custody of an IDM GIS user or system shall be regarded as property of IDM and hence shall conform to the municipal standards. These standards are as follows:

- All Spatial data shall be captured/delivered in the Hartebeesthoek 1994 LO 31 projected coordinate system;

- Alternatively, in non-projected spatial data, the Hartebeesthoek 1994 Datum shall be maintained;

- GPS standard - Assets capture: minimal accuracy is sub meter; Infrastructure planning: minimal accuracy is sub meter; Area assessments: minimal accuracy is 5 meters;

- All GPS data captured must be provided in Decimal Degrees;

- All datasets created or obtained from third party organizations shall always have updated metadata. This shall conform to the published Municipal metadata catalogue; and

- Municipal wide data sets must be maintained in a format specified by GIS Section and be updated in the corporate geographic database.

- When exporting to .jpg or .pdf use a resolution of 100 dpi (for printing hard copies 300 dpi is the recommended resolution) unless higher resolution is necessary to see detail. This reduces file sizes to accommodate file sharing and network limitations.

- Use Relative Paths Option when sharing .mxd's with others - Select the Document Properties option from the File Menu, followed by the Data Sources button in the "Map Title" Properties dialog. Then select "Store relative path names to data sources" and "Make relative paths the default for new map documents I create."

Commented [ME7]: Does this apply to officials of the IDM, systems of the IDM?
Can you please clarify for the reader.

Commented [LT8R7]: Noted

3.5 Departmental Responsibilities Workflow – New Project
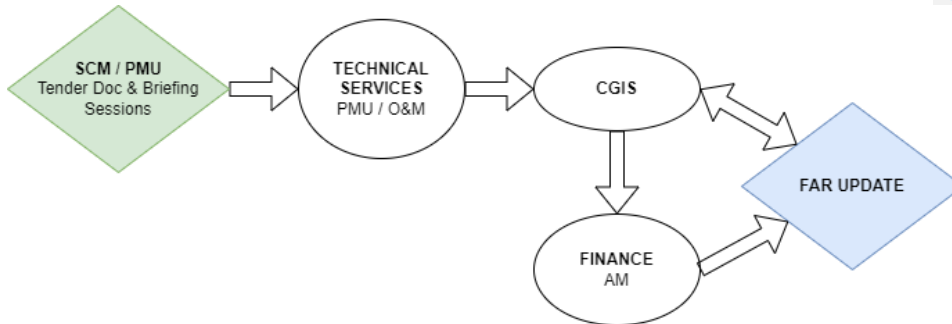
i. SCM and PMU through consultation with each other sets up the tender, ensuring that the Spatial and Attribute Information Management: Standard Operating Procedure is included in the documentation.

ii. Once the project commences, the Technical Services department is responsible for updating the GIS department on project progress, verifying if the work has been done on site (based on the tender terms of reference), and only signs off on a project once the required spatial information has been received, in the correct format/s, and verified by the GIS department.

iii. GIS department to inform Asset Management department of new infrastructure development, and provide an excel spreadsheet detailing new point and attribute data which includes the global ID to be used within the FAR.

iv. Asset management updates the FAR in Munsoft using the global ID as a unique key to link the FAR to the geodatabase. Each sub items/asset within that project site will receive a unique code which will consist of the GlobalID and an underscore with a number, starting at 1.

v. Asset Management provides GIS with the sub-sets as the final workflow for each project update.

3.6 Departmental Responsibilities Workflow – Maintenance/Upgrades
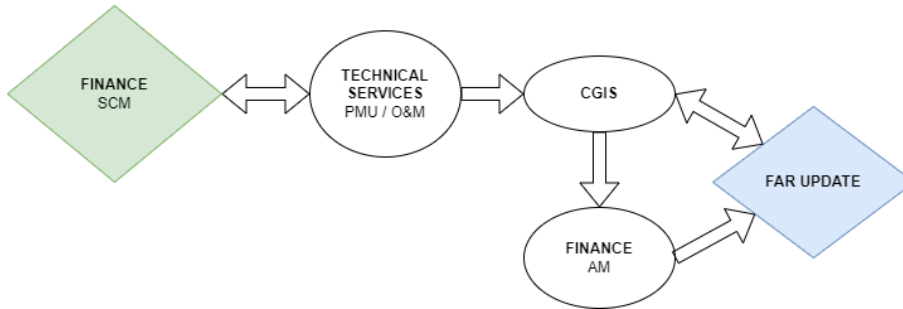
i. PMU/O&M requests a work order from SCM. SCM issues work order ensuring that the Spatial and Attribute Information Management: Standard Operating Procedure is included in the documentation.

ii. Once the work commences, the Technical Services department is responsible for updating the GIS department on work progress, and providing the required spatial information, in the correct format/s, to the GIS department.

iii. GIS department to inform Asset Management department of new or updated infrastructure development, and provide an excel spreadsheet detailing new point and attribute data which includes the global ID to be used within the FAR.

iv. Asset management updates the FAR in Munsoft using the global ID as a unique key to link the FAR to the geodatabase. Each sub items/asset within that work site will receive a unique code which will consist of the GlobalID and an underscore with a number, starting at 1.

v. Asset Management provides GIS with the sub-sets as the final workflow for each update.

3.7 Alignment to FAR

As the Water Services Authority, iLembe District Municipality (IDM) will be required to manage big datasets associated with water and sanitation infrastructure across multiple departments. The ArcGIS system offers IDM the most robust and accurate information management platform. By linking components from the IDM's Fixed Asset Register (FAR) to features in ArcGIS, data driven decisions can be made during the operation of infrastructure.

GIS is a versatile tool to maintain and update location information for both water and sanitation utility network assets. A GIS-centric asset management system therefore standardizes data and allows interoperability, providing users with the capability to reuse, coordinate and share information in an efficient and effective manner by making the ArcGIS geodatabase the actual asset registry as well.

The FAR for this project was provided in Excel format which was then integrated into the existing Geodatabase by way of a series of tables. These tables were assigned a unique ID which will enable them to be linked to the spatial layers in the GIS, yet they still remain autonomous and editable.

Linking the FAR to the geodatabase will be covered in more detail in Section 5 of this document.

For a comprehensive document relating to data management in the GIS, please see Annexure B: Operations and Procedures Policy, iLembe District Municipality.

4 Data Capture Workflows

The purpose of this section is to assist the user with the creation of geodatabase database schema, creation and management of data, and loading different types of data into the geodatabase.

The workflow on the following page illustrates the processes described above.

Sewer_Manhole
Sewer_MonitoringPoint
Sewer_OutfallSewer
Sewer_ReticulationSewerLine
Sewer_VIPs
Sewer_WastewaterTreatmentWorks
Sewer_WIP
SewerPumpStation
StudyArea
Water_AbstractionWorks
Water_Borehole
Water_BreakPressureTank
Water_BulkMeter
Water_BulkWaterPipeline
Water_Canal
Water_ConsumerConnection
Water_Dam
Water_MonitoringPoint
Water_PlasticTank
Water_PumpStation
Water_Reservoir
Water_ReservoirZones
Water_Reticulation

GDB

FIELDS
SUBTYPES
DOMAINS

CAPTURE NEW FEATURES

UPDATE FEATURE ATTRIBUTES
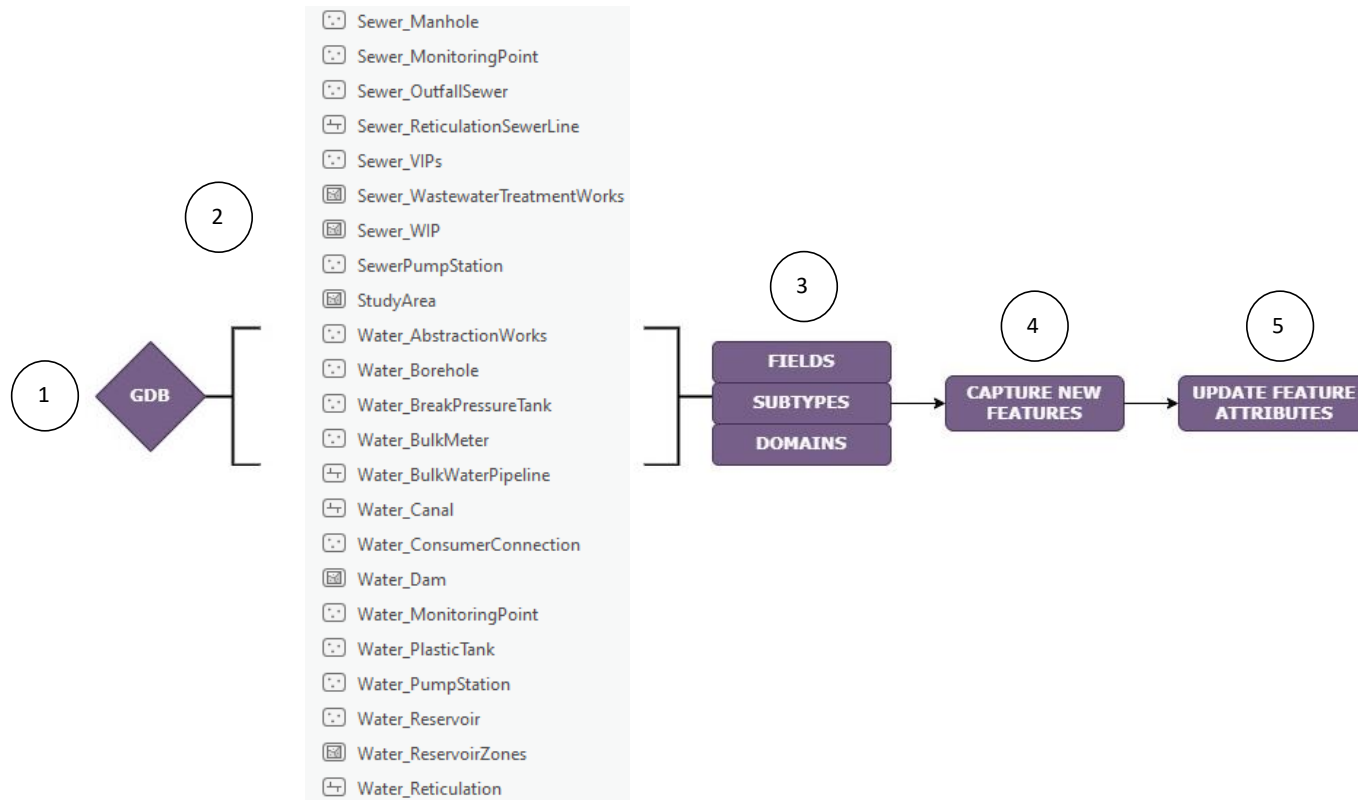
1. Create a Geodatabase

2. Create Feature Classes: Points, Lines and Polygons

3. Create and populate Fields, Subtypes and Domains

4. Capture new Features into the schema

5. Update Feature attributes and link to FAR

4.1 Test Case 1: Database schema

The following section will illustrate how to use a database schema that was setup in Excel to populate the geodatabase with the different feature classes, subtypes, domains and attributes.

4.1.1 Projection file

Spatial data provided to iLembe District Municipality will only be accepted in Geographic co-ordinates (longitude and latitude in decimal degrees) on the Hartebeesthoek '94 datum. A projection file was setup for this project and will be provided.

You can define your own projection file by following the steps outlined below:

- In the Table of Contents, right-click your map and go to Properties.

- Open the Coordinate Systems tab, locate and click the button that looks like a globe.

- Choose to Open a new coordinate system and make the necessary changes.
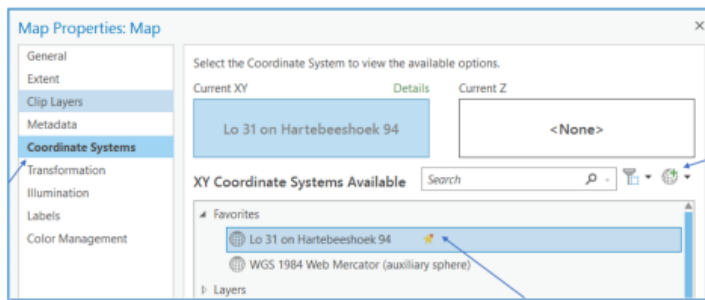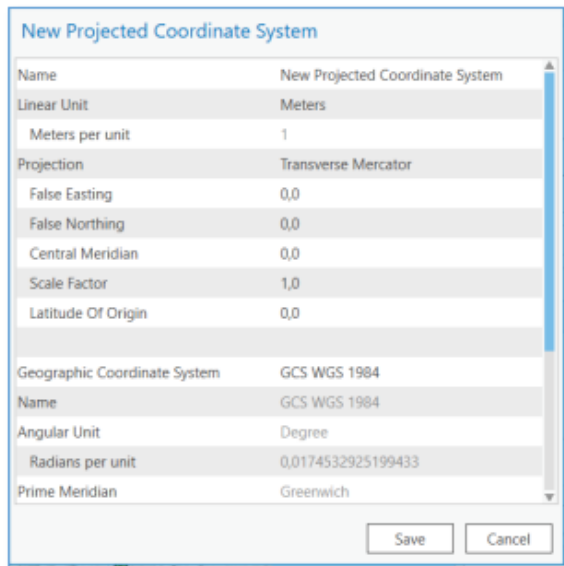
4.1.2 Create database

Map the folder where you need to work and create an empty geodatabase. For this test case we are going to work with the water reservoir points. You will therefore need to create a feature class for reservoirs.

- Right-click on the geodatabase | Select new | Add feature class

4.1.3 Add fields

- Right-click the feature class | Select design | Select fields

- Add the following fields to your feature class: Type, Asset ID, Asset Name, Province Name, District Municipality; Sub Place. Assign appropriate data types and parameters for the data to be captured or represented (text format, number format, other format).

4.1.4   Add a Domain

Domains are created and edited within their own tabular-style view called the Domains view. Within the Domains view, you can view existing domains, edit their properties and values, and create domains. They are used to constrain the values allowed in any particular attribute for a table or feature class. They provide a method for enforcing data integrity by limiting what can be placed on a field to a valid list or range of choices.

Right-Click on your geodatabase. Click on Domains.
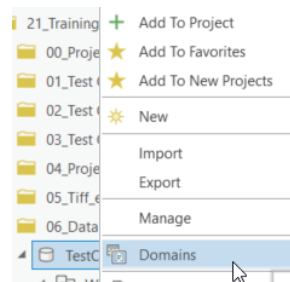
4.1.5   Create new Domain name

When opening the Domains dialogue box, the following options appear on the screen.

Domain Name	Description	Field Type	Domain Type	Split Policy	Merge Policy

Domain Name	Description	Field Type	Domain Type	Split Policy	Merge P
Sewer	Sewer	Text	Coded Value Domain	Default	Default

- Click in the domain name box and add the name for your domain (For example, "All_ProvinceName").

- Also select the DOMAIN TYPE. For this example, it is going to be "Coded Value Domain"

4.1.6   Create new Domain codes

As soon as you type in the domain name box, a second box of information appears on the right of the screen. This pane is where you will add the different codes or classes for your Domain, as per the example below:

4.1.7   Apply a Domain to a feature class

Click on the feature class you wish to apply your domain to and go to **Design**. Select the fields option.
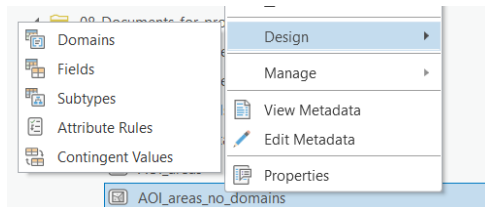
Click next to the field under the domain column and select the domain from the drop-down option. Save and close. Load the feature class into the view.

Field Name	Alias	Data Type	✓ Allow NULL	Domain	Default	Length
OBJECTID_1	OBJECTID_1	Object ID	☐			
Shape	Shape	Geometry	✓			
OBJECTID	OBJECTID	Long	✓			
Scheme_Nam	Scheme_Nam	Text	✓			50
Label	Label	Text	✓			
NRWToR	NRWToR	Text	✓			
WSSCode	WSSCode	Text	✓			
Shape_Leng	Shape_Leng	Double	✓			

<Add New Coded Value Domain>
Sewer

4.1.8   Create a new Subtype

Subtypes are a subset of features in a feature class, or objects in a table, that share the same attributes. They are used as a method to categorize your data. For example, the pipe material in a Water Reticulation feature class could be categorized into three subtypes: HDPE, uPVC, and mPVC.

Subtypes allow you to do the following:

- Set default values on fields in each of the subtypes that will automatically apply when creating new features. In the above example, the HPDE subtype could have the default value for a cost per meter attribute set to R150/meter, while the default value for the uPVC subtype could be R200/meter. Whenever a new HDPE line is added to the feature class, its cost per meter attribute will automatically be set to R150/meter. Whenever a uPVC line is added, the cost per meter attribute will automatically be set to R2000/meter.

- Apply coded or ranged domains to the fields of a subtype, enabling you to constrain input information to a valid set of values. For example, in a feature class for water mains, a range domain for water pressure can be implemented. The subtype representing HDPE water mains can have a pressure between 40 and 100 psi, while the subtype for uPVC water mains can have a pressure between 50 and 75 psi.

- Each subtype may have different connectivity, relationship, or topology rules associated with it.

- Increase the performance of the geodatabase by representing a variety of real-world objects as a subset of features in a given feature class instead of creating new feature classes for each object.

- Create customized rules between features using written code.

Subtypes are created on individual feature classes:

- In the catalogue pane, right-click the Reservoir feature class and select Design.

- On the Subtypes tab, click on Create/Manage subtypes.
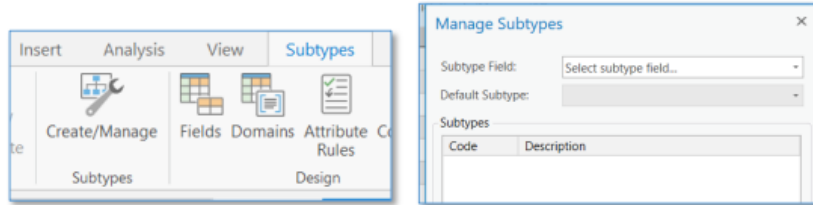
- Select the field you would like to apply the subtype to from the drop-down list.

- Enter the coded values for your subtype in the dialogue box, and when finished, click save.

SubType Code	SubType Description
1	Concrete-Ground
2	Concrete-Underground
3	Steel Tower
4	Steel Tank
-100	No data

4.1.9   Capturing new features

To verify that your Domains and Subtypes are working correctly, you will create some new features in your feature class.

- Add the Reservoir Feature Class to your view.

- Go to the Edit tab and click on the **Create** option.
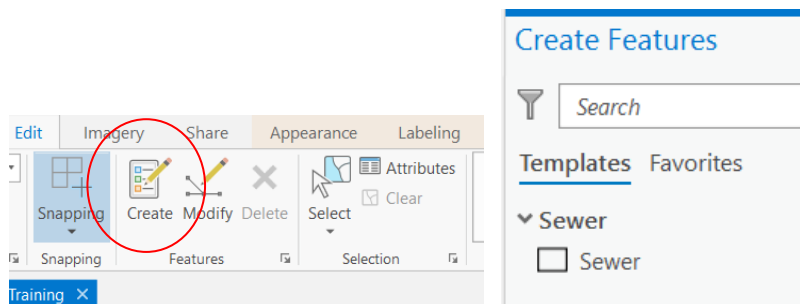
- When you click on the Create button, the available templates for your map will be available on the right-hand side of your view.

- Select the feature template you wish to edit, choose an apropriate editing tool, and add a new feature to the map.
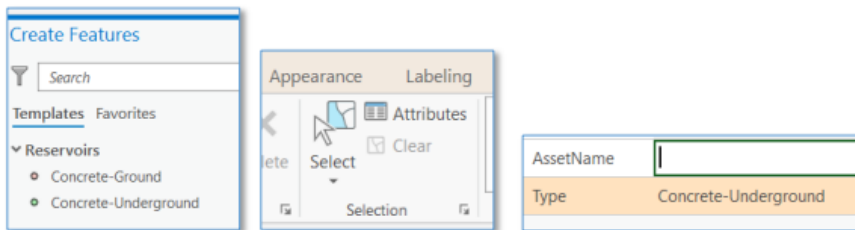
- Once you have added your new feature, and it is still selected, on the edit tab click on the attributes button to edit the attributes of your new feature.

- Find the Type field in the attribute list that opens, click in the cell next to it, and a drop-down list of attributes should be available for you to select your subtype/domain. Make the necessary selection and click on save to save your edits.

4.1.10   Editing feature attributes

Make sure that you set the layer that you want to change as the selected layer. Right click on the layer and go to SELECTION. Select the option to Make this the only selectable layer.

Next, click on the select option from the Map tab, then select a feature to edit its attribute values. Click on the ATTRIBUTES option. All the relevant fields for your selected feature will show. Click on the fields to see the drop-down domain settings.
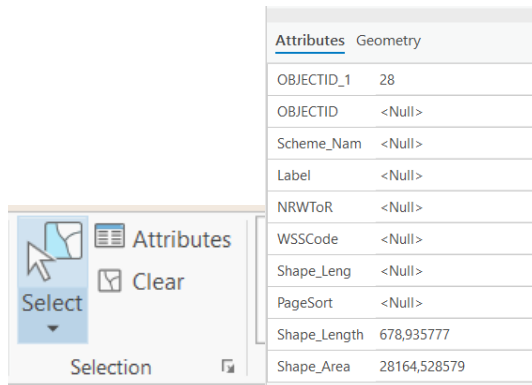
4.1.11 Using symbology

Note that even before you add the values from the domain to your fields, when you use unique symbology on this specified field it will show all the values currently in the domain setting.
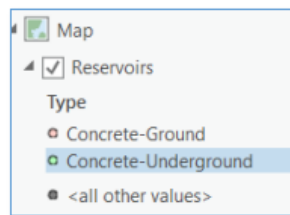
If the list on the field doesn't display correctly, you need to either manipulate the data or add new options to your Domain or Subtype settings.

4.1.12 Field/Attribute changes

Make a backup copy of the original data before doing any changes. Load the reservoir data into the view and open the attribute table to check how the different fields are being used.

- First, we want to change the field names so that they are the same as the new database schema.

- Remove the reservoir feature class from the view.

- In your Catalogue pane, within the geodatabase, right-click the Reservoir feature class.

- Add a new field with the correct name, for example "Asset Name"

- Load the data into the view and open the attribute table

- Select your new field and use the field calculator to populate the field. When you are done, remove the old field (right-click the field name and click Delete).

4.1.13   Changes on field "Type"

The TYPE field uses either a Domain or Subtypes. You need to check against the spreadsheet what numeric values are associated with a specified text value. When checking the data, no clear field were found do make the correct changes to the TYPE field, therefore you need to change all show the no data option.

- Right click on the feature class, go to the attribute table, go to calculate field

- Type "-100" and click ok

- Note that the correct "No data" will only show when loaded into the correct database schema.
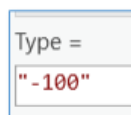
4.1.14   Changes on field "Status"

The STATUS field uses either a Domain or Subtypes. You need to check against the spreadsheet what numeric values are associated with a specified text value. Using manual steps repetitively, you need to clean up the data so that it fits your new schemas. You can use the Definition Query functionality to manipulate the data.
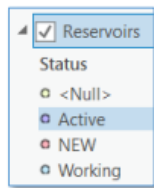
- Right-click on the feature class and open Properties.

- Click on the Definition Query tab.

- Click on New Definition Query

- Select the Status field and the value of active, click on apply and then click OK.
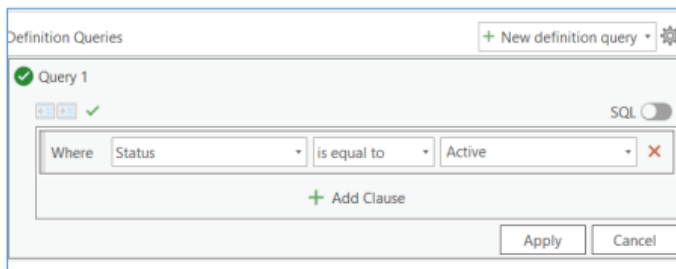
- Right click on the feature class and open the attribute table.

- Go to Calculate Field.

- When checking the spreadsheet, you can use number 2 (Approved), assuming that this is the

  correct value that is needed.

- Right-click on the status field and open the calculate field option

- Type the value "2" and Click OK.

4.1.15   Changes on field "Asset Name"

Next you need to manipulate the data within a field. However, the field "Asset Name" does not have any Domains or Subtypes that could help us, so you need to clean up the attributes manually.

- Right-click on the feature class and open the attribute table.

- Click the add button and add a temporary text field called "Temp1"

- Right click your new field heading and select Calculate Field.

- Double Click the existing Asset Name field to add it to your expression.

- Next, in the helpers panel of the Calculate Field tool (right-side), scroll to and select "title()" to complete your expression. Click Apply.
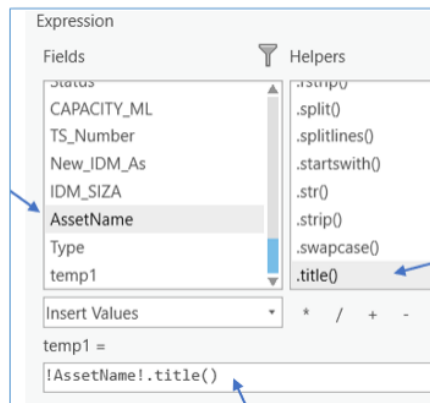
- Check the Temp1 field to see if the data manipulation work correctly. If so, copy the new values from the Temp1 field back into the Asset Name field.

4.1.16 Unique ID

When you are done with adding the feature class to your database, you can activate the unique Global IDs. Global IDs are used to uniquely identify a feature or table row in a geodatabase and across geodatabases. This needs to be done manually on each of the feature classes.

- In the catalogue pane, right-click on the feature class and go to Manage – Add Global ID's

- Click Ok.
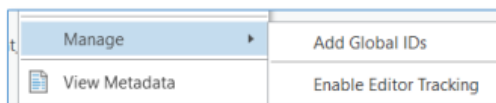
4.1.17 Appending data to the new geodatabase

When you are done with manipulating and cleaning of the data, you will need to transfer the data to the final geodatabase schema.

- On the Analysis tab, click the Tools button, and search for the Append tool.

- Select the appropriate input and output datasets

- Use the field map to reconcile field differences option to make sure that you map the data correctly before loading it into the geodatabase.

4.2 Test Case 2 – Importing data from non-GIS formats

Data received from clients/contractors may often be in a format that is not easily converted into ArcGIS. In these instances, you will need to get the data "ArcGIS ready" by preparing and/or cleaning it before importing into the geodatabase. Open Excel and add the following coordinates into your

empty spreadsheet. The existing coordinate system of the data needs to be known as well as what the data represents and where it is expected to be located spatially on at least a municipal level.

Pipe design data.		
Reference	Y	X
PI1	-25300.674	3251861.000
PI2	-25390.653	3251859.073
PI3	-25406.649	3251858.720
PI3a	-25408.649	3251858.676
PI4	-25467.572	3251839.389
PI5	-25545.570	3251838.780
PI6	-25573.508	3251836.915
PI6a	-25575.503	3251836.782
PI7	-25619.426	3251834.171
PI8	-25690.312	3251821.552
PI9	-25733.845	3251819.837
PI10	-25768.242	3251818.274

SG Diagrams (such as those used to compile CAD data) capture their XY points opposite to GIS systems, and therefore need to be converted to GIS before they will display correctly in a GIS system. The following exercise is an example of how to convert SG Diagram coordinates into GIS coordinates.

4.2.1 Cleaning data in an Excel sheet

You will need to clean the data before importing it into your database.

- Make sure that the Code/Name/ID are correct.

- Copy the x and y coordinate fields to new fields (you can keep the original fields for verification and remove them later).

A	B	C	D	E
Code	y	x	Y-coord	X-coord
PI9	-25733,845	3251819,837	-3251819,837	25733,845
PI10	-25768,242	3251818,274	-3251818,274	25768,242
PI1	-25 802 205	3251816,679	-3251816,679	25802,205
PI11a	-25 804 203	3251816,585	-3251816,585	25804,203
PI12	-25847,143	3 251 790 948	-3251790,948	25847,143
PI13	-25 855 979	3251786,289	-3251786,289	25855,979
PI13a	-25 857 758	3251785,352	-3251785,352	25857,758

- Note the X and Y are switched around

- Make sure to change the negative and positive values

- Remove the point and replace with comma (This could be swopped around on some laptops)

- Check all fields for mistakes

4.2.2 Setup the map for importing data

Set up an empty map that you can use to make sure the projection for the coordinates is used correctly.

- On the INSERT tab, Select New Map.
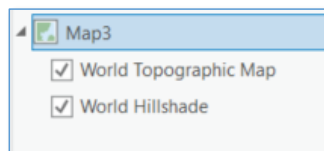
- Once created, right-click your map heading and go to properties.

- Navigate to the COORDINATE SYSTEMS menu.

- Import the projection file into your map.
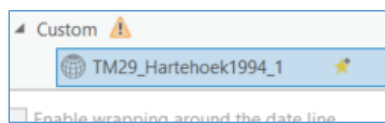
- Right-click the projection file and add to favourites.

4.2.3 Create points from an Excel file

In the Catalog pane, navigate to the spreadsheet you created in the previous steps.
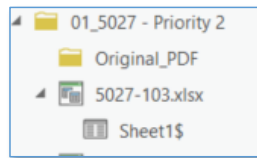
- Right-click SHEET and select **Display XY Data**

- Assign the X and Y fields to the cleaned fields you created in your spreadsheet and make sure to check that the Coordinate System is referencing the one you just loaded into your map. Run the tool.
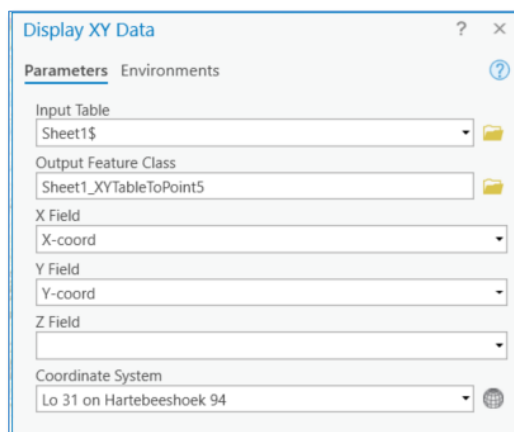
- It is important to note that the output of the Display XY Data tool is only a temporary point file that is displayed. In order to make this data permanent, you will need to export it to your geodatabase as a new feature class.
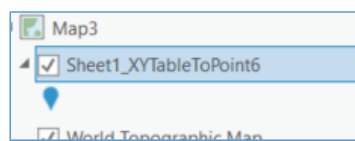
- Right-click the newly created point layer, select **Data** and export the feature class to your geodatabase.

- Remove the temporary layer from your map and replace it with your newly created feature class.

- Not all the attribute values can be extracted this way and it is possible that you must navigate back to the original PDF to get more information.

4.3   Test Case 3 – Georeferencing from a PDF Diagram

Digitizing in GIS is the process of "tracing," in a geographically correct way, information from images/maps. The process of georeferencing relies on the coordination of points on the scanned image (data to be georeferenced) with points on a geographically referenced data (data to which the image will be georeferenced). By "linking" points on the image with those same locations in the geographically referenced data, you will create a polynomial transformation that converts the location of the entire image to the correct geographic location. We can call the linked points on each data layer control points.

It is not possible to georeference a PDF file directly in ArcMap. ArcGIS does not support PDF as an input format. The PDF file must be converted to a supported raster format, such as JPEG or TIFF, and be added to ArcMap before georeferencing.

Converting the PDF file to a supported raster format can either be done by:

- Scanning the PDF document.
- Taking a screenshot of the PDF file.
- Using an online conversion tool.
- Using the 'PDF to TIFF' tool.

4.3.1   Snapit Tool

Use the Snapit tool to extract the part of the PDF that you want to use into a PNG format.
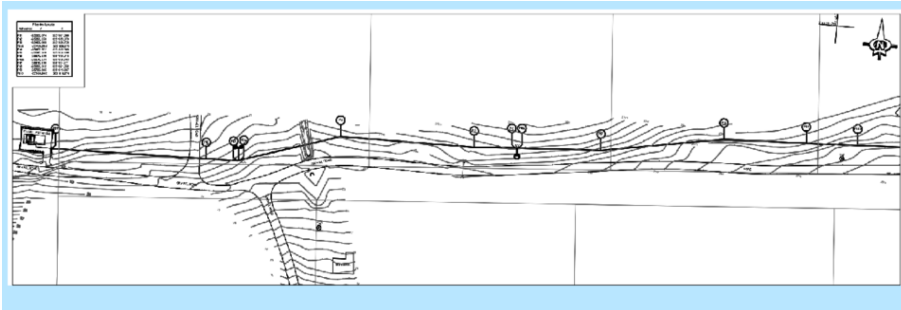
4.3.2   Load PNG into map

When the BUILD PYRAMIDS pop-up appears on the screen select the YES option.
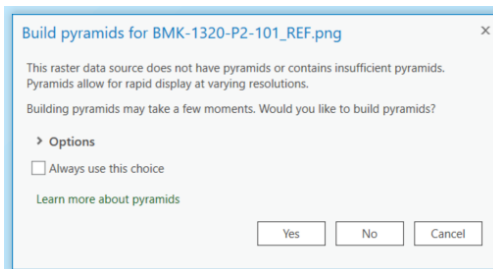
4.3.3   Create TIFF

Use the PNG file to create a TIFF file so you can reference it and digitize some of the relevant information.

- In your catalogue view, right-click your .png file and select Export Raster

- Set the projection and the path for the export raster file

- Make sure that the TIFF extension is added to the file

4.3.4   Georeferencing

Use the TIFF file to georeferenced the image to the correct place in the study area.

- Add the newly created TIFF image to the map

- The Build Pyramids pop-up appears

- Use the default settings (build, calculate are ticked on) and select ok

- Click on the IMAGERY tab

- Click on the GEOREFERENCE tab
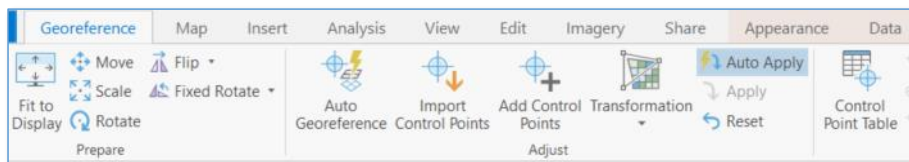
- Add control points (at least four points)

- First zoom to image and add point, then zoom to your feature class layer and select point

- Click on Auto Apply

- Save your updates

- Click on Save as New (export to correct path)

4.3.5   Digitizing new features

Using the georeferenced TIFF image as your reference, digitize new points.

- Click on the EDIT option, then select create

- Depending on what feature class is loaded, click on the attribute in the template (right-side view) and start digitizing.

- Click on the attributes option and add attributes, click on the save edits option to save.
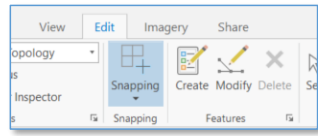
4.4 Working with CAD Data in ArcGIS Pro

In the succeeding paragraphs, an overview will be provided for working with CAD data in ArcGIS Pro. This standard operating procedure aims to provide guidance on best practice workflows to convert CAD Data into Geodatabase Feature Classes. The workflow described assumes that AutoCAD and/or MicroStation are not available to the GIS Professional using ArcGIS Pro.

4.4.1 Adding CAD Data to ArcGIS Pro

ArcGIS Pro accepts data generated by AutoCAD and MicroStation-based applications and other applications that use the DGN, DWG, and DXF file formats. ArcGIS Pro also reads other Feature Class content in AutoCAD DWG and DXF format files from AutoCAD Civil 3D and Esri's ArcGIS for AutoCAD.

After the creation of a map project from the home tab of ArcGIS Pro, CAD Data is added by establishing a folder connection in the Catalog Pane of ArcGIS Pro.
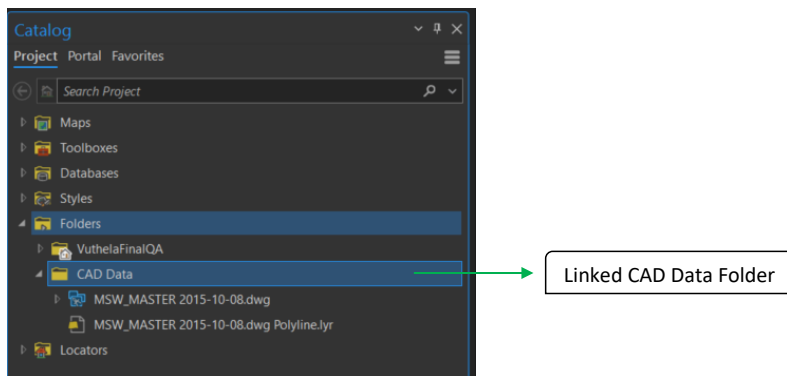
Figure 1: Catalog Pane showing CAD Data Folder Connection

After establishing the folder connection, a CAD Feature Dataset containing five CAD Feature Classes is generated. By expanding the CAD Feature Dataset, the following feature classes appear:

- Annotation;
- MultiPatch;
- Point;
- Polygon; and
- Polyline.

These CAD Feature Dataset and CAD Features Classes are automatically generated by ArcGIS Pro and are standard across all DWG, DGN and DXF file formats.
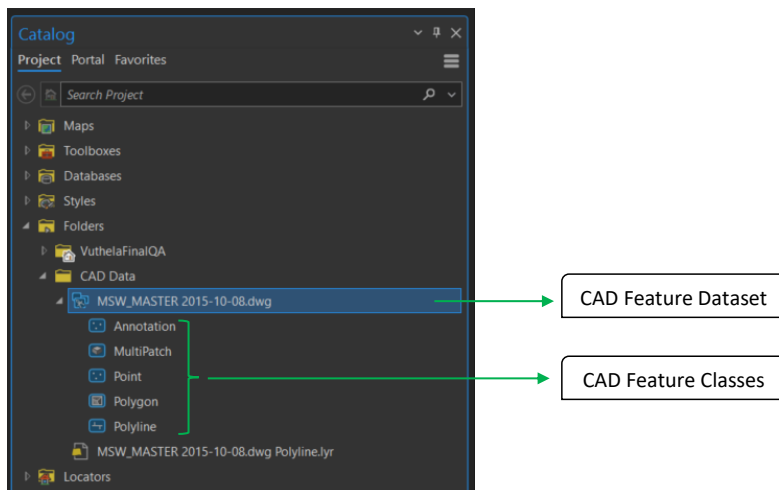
Figure 2: Expanded CAD Feature Dataset in Catalog Pane

CAD objects (Lines, Splines, Circles, Text, Block, Arc, 3D face, etc.) used in AutoCAD and MicroStation to create the CAD model are automatically stored in one of the five CAD feature classes. Further details on how ArcGIS Pro transforms CAD objects into CAD feature classes can be found here. (*https://pro.arcgis.com/en/pro-app/latest/help/data/cad/supported-autocad-and-microstation-geometry.htm*)

4.4.2   Adding CAD Data to a MAP

CAD Feature Classes can be added to the Map of the project by right clicking the CAD Feature Dataset and selecting 'Add To Current Map'.
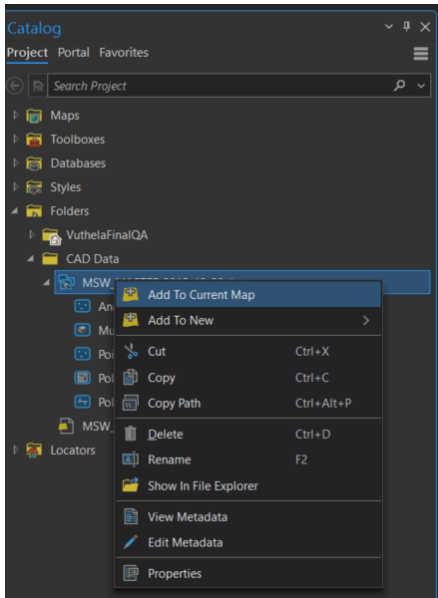
Figure 3: Adding CAD Feature Classes to the Map

Once added, CAD Feature Classes are moved to the Content pane. Each CAD Feature Class is automatically organized into a Group . Each Group is named by combining the CAD file name with the Feature Class name. 'CAD File Name + Feature Class Name'.
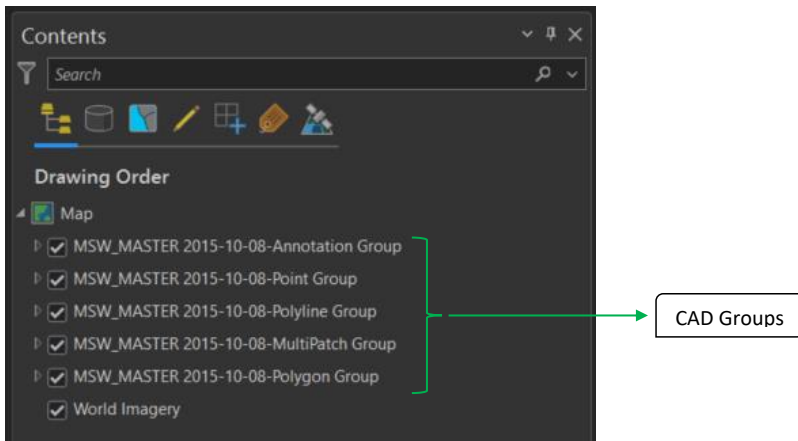
Figure 4: CAD Feature Class Groups in Content Pane

Each CAD group contains Feature Classes that match the Layers used in the CAD model space. Most commercial CAD applications organise CAD objects (Line, Spline, Circle, Text, Block, Arc, 3D face, etc.) in Layers. Each Layer can contain a combination of CAD objects as set up by the CAD Professional. As an example, a Layer called *Pipes* can contain Lines, Circles, Annotations and Text. ArcGIS Pro will create a Feature Class for each of the Layers and automatically group the Feature Classes into one of the Four CAD Feature Class types (Point, Polyline, Polygon and Multipatch).
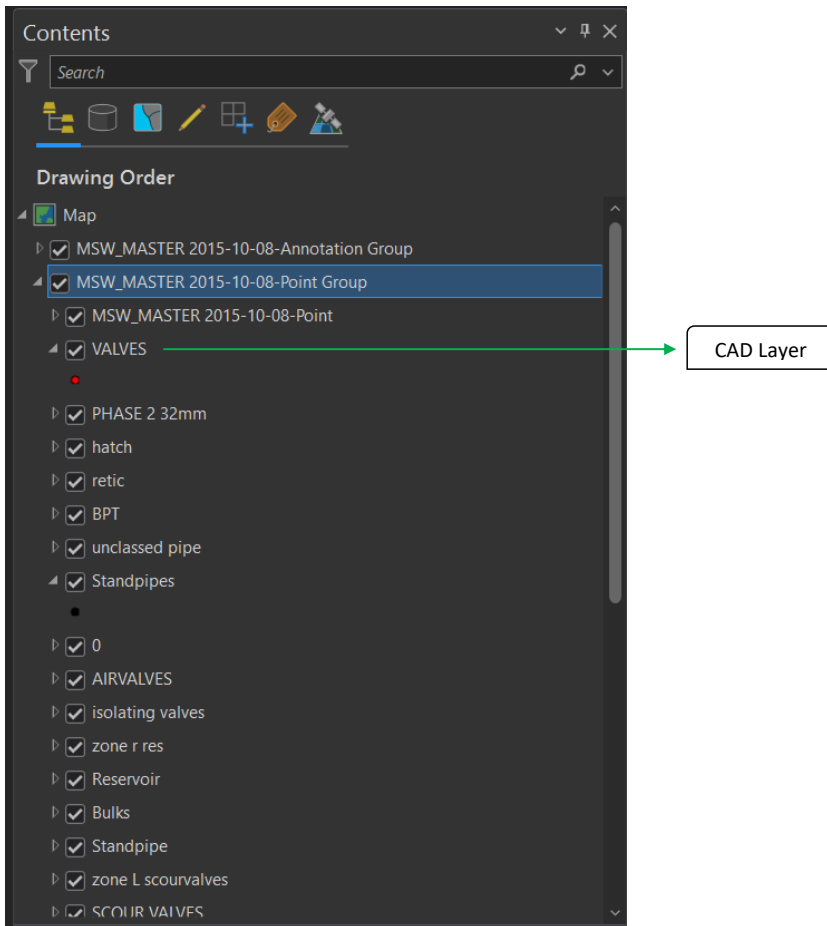
Figure 5: Point Group Expanded with Point Features named According to CAD Layers

We see how this CAD model has multiple CAD Layers. In this instance a Layer called *VALVES* is present in the model. If, as an example, the CAD Professional decided to provide an Annotation for the *VALVE*, the *VALVES* Feature Class will appear in the Annotation Group resulting in two points stacked on top of each other in ArcGIS. One point will represent the valve and the other will represent the annotative text showing the type of valve. The GIS Professional needs to become comfortable with the conversion between CAD objects and GIS Feature Classes as documented here. (*https://pro.arcgis.com/en/pro-app/latest/help/data/cad/supported-autocad-and-microstation-geometry.htm*)

After initially adding CAD Feature Classes to the Map, the Features are read-only and cannot be edited. To overcome the read-only state of Features, a Georeferencing and data conversion process needs to be performed as outlined in subsequent paragraphs.

4.4.3   Georeferencing

There are multiple reasons why CAD Data does not appear in the correct Geographic location when added to a Map in ArcGIS Pro. One of the more common explanations is the use of Cartesian coordinates by CAD Professionals or the use of a false-easting or northing to prevent the use of long numerical numbers in the CAD model space. To illustrate how ArcGIS Pro interprets the coordinates of a CAD model, consider the rectangle shown in the AutoCAD model space with cartesian coordinates indicating the X and Y locations of the vertices.
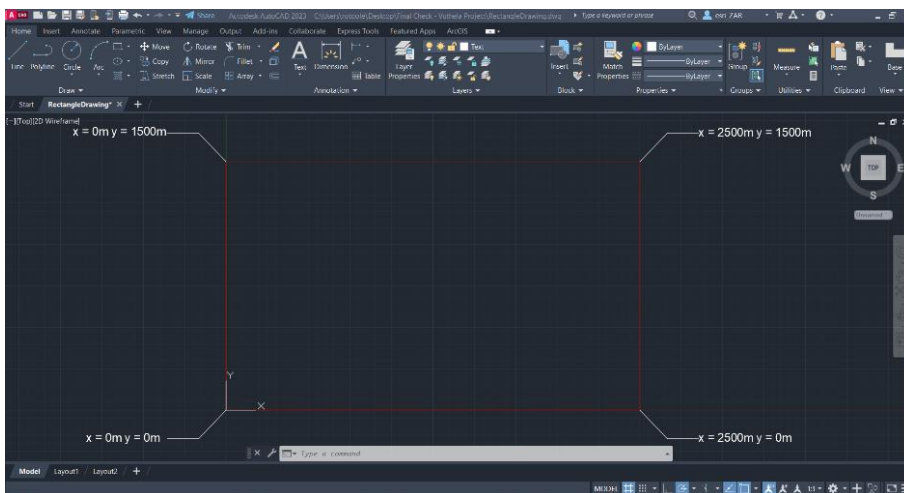
Figure 6: Rectangle in AutoCAD Model Space

When adding the CAD drawing to ArcGIS Pro and zooming to the layer extents, it becomes clear that ArcGIS Pro plots the CAD Feature Classes at the origin of the Basemap's Coordinate system. In the case of the rectangle, the Basemap used in ArcGIS Pro is in the Local Hartebeesthoek Lo 31 Projection. The bottom left vertex of the Rectangle is at a Longitude of ~ 31 degrees East and 0 degrees South. Each of the remaining vertices plot at a Longitude and Latitude that match the distances created in CAD. In this case 2500 m East and 1500 m North.
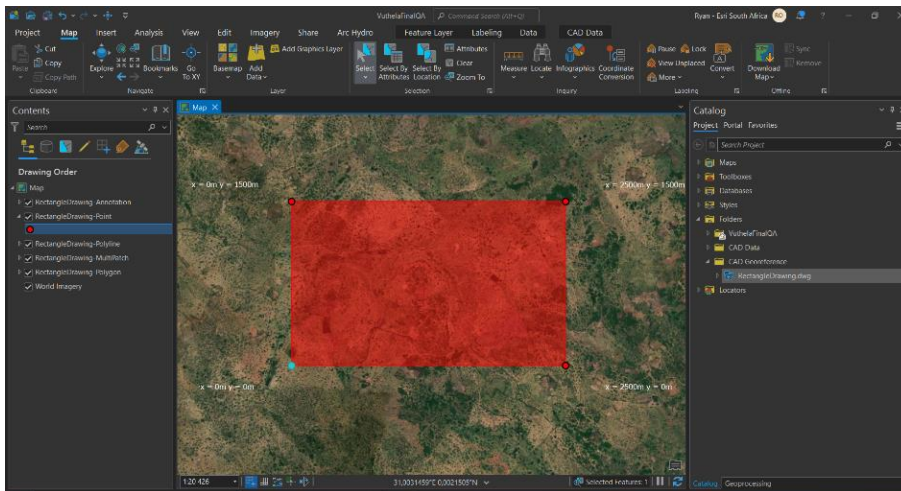
Figure 7: Rectangle added to ArcGIS Pro Map Space

It is always recommended to move the CAD objects in their source environment, this document however, assumes the GIS Professional does not have access to a commercial CAD application and the following paragraphs will explain how to move the CAD Feature Classes to the correct geographic location.

To move the CAD Feature Classes, the GIS Professional needs to have some sort of idea where the correct geographic location of the drawing is. Typically, most As-designed and As-built drawings have Setting Out Points (*SOPs*) that can be used as reference. If SOPs are not present, it is recommended that the GIS Professional study the CAD drawing to look for other clues like street names, erf boundaries or other descriptors that may indicate location. Once a location has been established, it is recommended that point Feature Classes be created and digitised at the known locations on the Map. To demonstrate the process, let's consider the rectangle. Let's assume the rectangle represents an Erf boundary on an empty plot of Land in KwaDukuza. The following process is recommended:

4.4.3.1   Create Point Feature Class to Represent SOPs
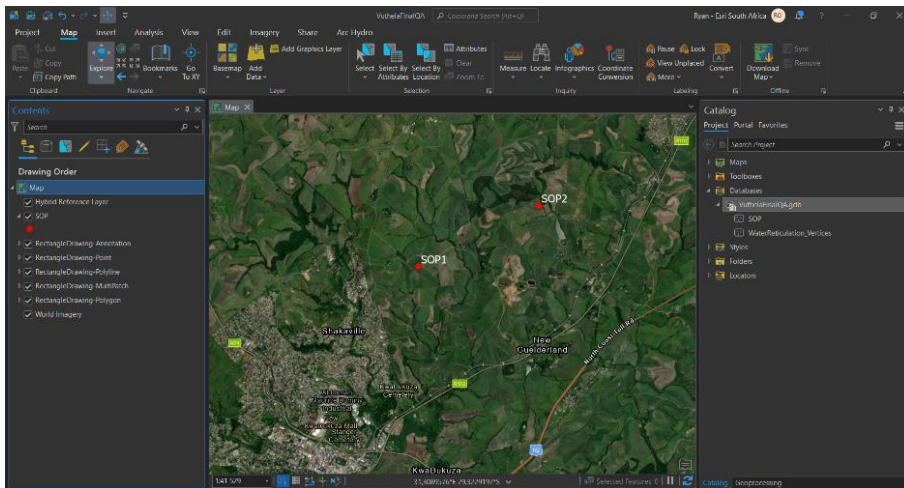
Figure 8: Point Features (SOPs) Representing Two Known Locations

4.4.3.2   Select CAD Feature Class to Move

It is recommended to only select one of the CAD Feature Classes in the Contents pane. In this case, we will work with the Polygon Feature Class. Once selected in the Contents pane, ArcGIS Pro will automatically recognise that this is a CAD Feature Class and the CAD Data Tab will appear on the Ribbon. By selecting the Tab, ArcGIS Pro displays panels that contain tools to assist in the Georeferencing and data conversion process.
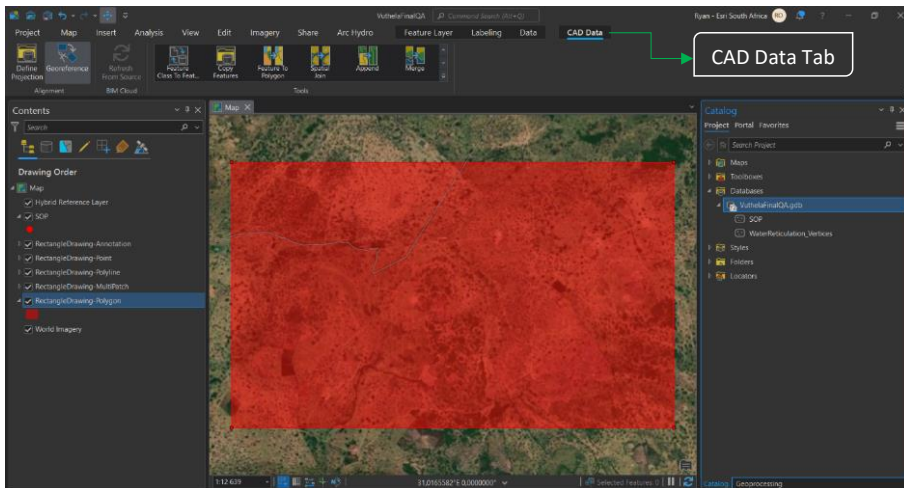
Figure 9: CAD Data Tab on ArcGIS Pro Ribbon

4.4.3.3   Georeference CAD Feature Class

a) Select the 'Georeference' tool from the Alignment panel;

b) On the Georeference tab select the 'Add Control Points' tool from the Adjust panel;

c) Once the 'Add Control Points' tool is selected, the cursor will change to a cross asking the GIS Professional to select the point source (the Source). In this example, the lower left corner of the rectangle is selected;

d) After selection, pan to the correct Geographic location and place the cursor on the known Geographic point (the Target). In this case we select SOP1;

e) Repeat steps c) and d). By increasing the number of Source to Target iterations using the 'Add Control Points' tool, the accuracy of the Georeferencing process will increase;

f) After completing the Source to Target iterations, click Save on the Save panel and close the Georeference tab.

It is important to note that the above process automatically scales the drawing and that the process only needs to be performed with one CAD Feature Class. All other Feature Classes will now automatically reference the Georeferenced Feature Class and move accordingly. ArcGIS Pro will also generate two additional files and save them in the folder location of the source CAD file. These files are a World File (. wld3) and Projection File (.prj) with the same name as the CAD file. Any updates to

the drawing need to be saved to the same folder location and given the same name as the World and Projection files to ensure the Georeferencing is not lost.

Figure 10: World and Projection File Generated by ArcGIS Pro

The World file indicates to ArcGIS Pro how many units a CAD drawing needs to move from its source X, Y, Z location to its target X, Y, Z location. The Projection file provides information about the projected or geographic coordinate system used.
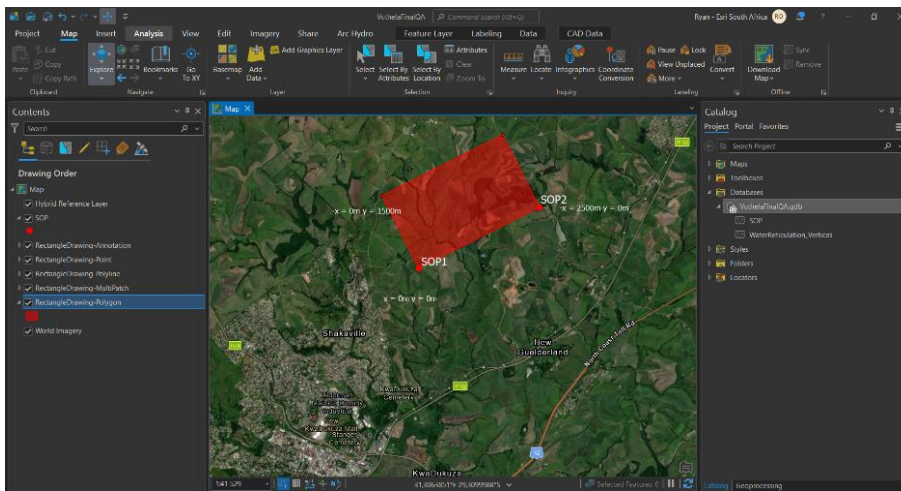
Figure 11: Georeferenced Rectangle

4.4.4   CAD Data Conversion

After completion of the Georeferencing process, CAD Feature Classes need to be converted from their read-only state to Feature Classes stored in a Geodatabase that can be edited and shared to the ArcGIS

Online or ArcGIS Enterprise portal. There are multiple Geoprocessing workflows that can be used to convert read-only CAD Feature Classes to editable Feature Classes that are stored in a Geodatabase. The succeeding steps will highlight how the 'Feature Class to Feature Class' Geoprocessing tool is used.

4.4.4.1   Select CAD Feature Class to Convert

It is recommended that the GIS Professional have a clear understanding of what CAD data is required in GIS to prevent unnecessary conversion of all CAD Feature Classes.

- Select the Feature Class in the Contents pane that requires conversion;
- On the CAD Data tab in ArcGIS Pro, select the 'Feature Class to Feature Class' tool from the Tools panel. Populate the Graphical User Interface of the 'Feature Class to Feature Class' tool by giving the output Feature a name and Geodatabase location;
- Select Run to perform the task.
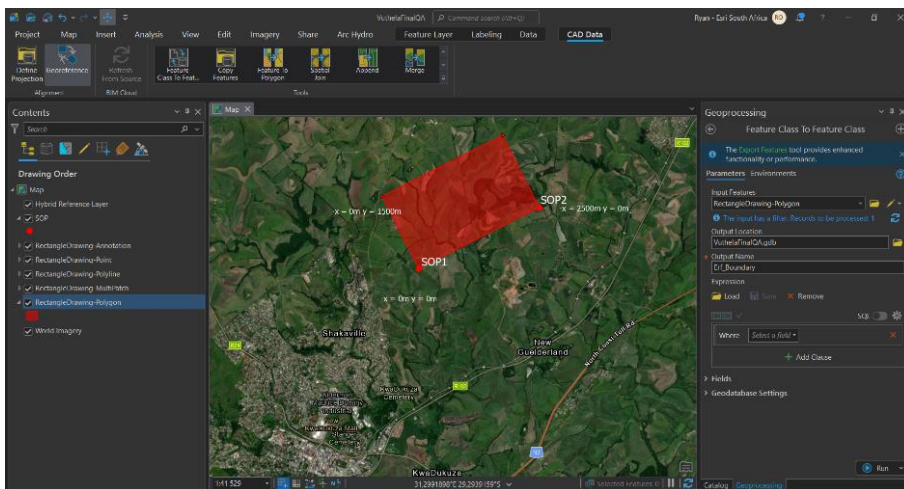
Figure 12: CAD Feature Class Conversion - 'Feature Class to Feature Class' tool

After the Geoprocessing tool has Run, the CAD Feature Class has now been converted into a GIS Feature.
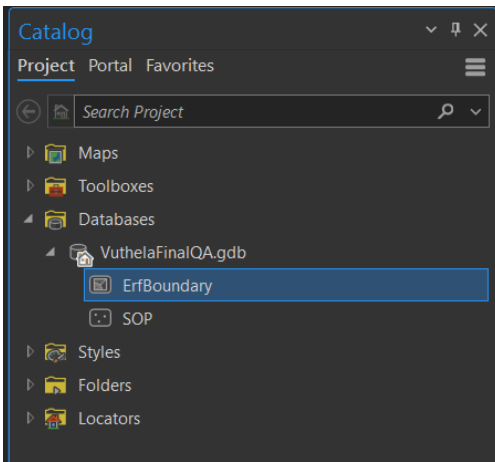
Figure 13: Converted CAD Feature Class Stored in a Geodatabase

4.4.5   Closing Remarks/Recommendations

- The workflow recommended in this document needs to be treated as a guideline;
- Converting CAD Data into Feature Classes is an iterative process that may require more steps than recommended in this document;
- Any geometric changes made in GIS do not dynamically update in CAD models. It is recommended that any major geometric changes be made in source CAD applications and then shared to GIS;
- It is recommended that ArcGIS Pro be used to clean and edit converted CAD Feature Classes before sharing to ArcGIS Online or ArcGIS Enterprise;
- It is recommended that Georeferencing be done in the source CAD application; and
- When the GIS Professional is comfortable with both CAD and GIS applications, the ArcGIS for AutoCAD plugin is recommended.
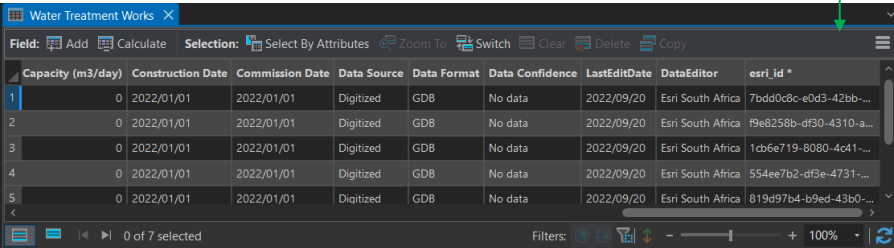
5   Linking the FAR to the GIS

In the succeeding paragraphs, steps will be provided to guide GIS professionals, consultants and other stakeholders in the process of linking the Fixed Asset Register (*FAR*), the master data on water and sanitation infrastructure, with the GIS Feature Classes.

The creation and maintenance of unique ID's to link the spatial data with its related FAR attributes is the responsibility of the CGIS department of the IDM. These unique ID's are the way in which attributes from the FAR are linked to the spatial features in the geodatabase.

5.1   Assignment of unique ID's

During the completion of the data loading process, Esri South Africa (*Esri*) assigned a 36-digit unique ID to each record present in the Attribute Table of a Feature Class. This 36-digit unique ID serves as the GIS ID for each asset.   The unique ID was added to a Field named 'esri_id' and appears in each Feature Class.

GIS ID

Figure 14: esri_id In Attribute Table of Water Treatment Works Feature Class

5.2   Joining Feature Classes to FAR tables

The esri_id created in each record of the Feature Class, was added to the matching records in the FAR. To join records in the FAR to records in GIS, a 'Relate' needs to be created:

1. Select all records in the FAR that represent the components of the asset;

2. Copy records and paste on a clean sheet in excel;

3. Use the 'Excel To Table' geoprocessing tool in ArcGIS Pro to convert the newly created excel table (containing all the relevant records from the FAR) to a table in ArcGIS Pro;

4. Add the newly created table to a new map, with its corresponding spatial feature class;

Figure 15: Excel to Table Geoprocessing Tool

5. Use the 'Add Relate' geoprocessing tool in ArcGIS Pro to link the table containing all the records from the FAR to the Feature Class. Note the following for inputs into the 'Add Relate' geoprocessing tool:

   ▪ **Layer Name or Table View =** The Feature Class containing the GIS records of the asset;

   ▪ **Input Relate Field =** The 'esri-ID' field;

   ▪ **Relate Table =** The created standalone table of FAR attributes

   ▪ **Output Relate Field =** The 'esri-ID' field;

   ▪ **Cardinality =** One to many
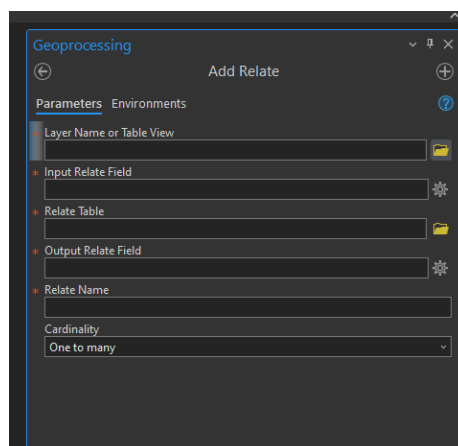
Figure 16: Add Relate Geoprocessing Tool

5.3   FAR Updates:

In addition to linking existing records between the FAR and the geodatabase, users will also need to capture new information into these tables at times where updates are necessary (for example, where a new asset is introduced, or alternatively, decommissioned).

5.3.1   Additions to the FAR:

When a new component is added to the FAR, the esri_id (Generated by Esri) associated with all other components at that facility or with a particular section of pipe, needs to be copied and added to the new record. Steps 1 to 4 will then be repeated. It is recommended that the FAR be reconciled with the GIS bi-annually.

5.3.2   Newly built Infrastructure:

Any newly built water and sewer infrastructure needs to be captured in both the FAR and GIS. To generate a unique ID for use in both the FAR and GIS, a Global ID field can be added to the newly created GIS Feature Class and copied over to the FAR. A Global ID field is created and populated as follows:

- Right click the Feature Class in the GDB;
- Select Manage;
- In the Feature Class Properties Dialogue box check the 'Global ID's' box and select OK. A global ID field will now be added to the Feature Class. When adding data to the Feature Class, a unique ID will automatically be generated. The unique ID will be copied into the FAR.
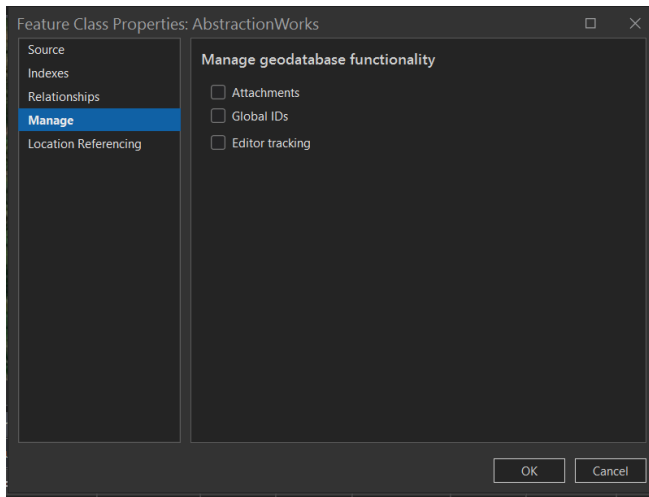
Figure 17: Feature Class Properties Dialogue Box

Figure 18: Sundumbili Water Treatment Works – Feature Record joined to Asset Component Table from FAR
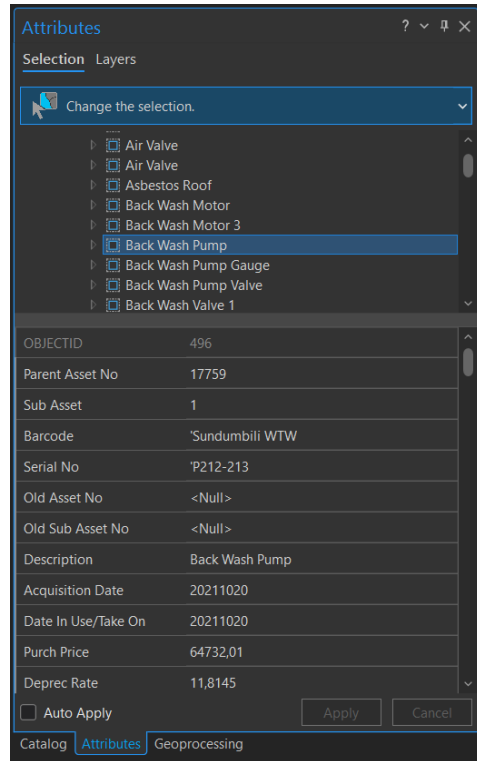
Figure 19: Sundumbili Water Treatment Works - Asset Component Table Linked to Feature Class

6 Metadata

Metadata is information about data. Similar to a library catalogue record, metadata records document the who, what, when, where, how, and why of a data resource. Geospatial metadata describes maps, Geographic Information Systems (GIS) files, imagery, and other location-based data resources.

Organizations can create and share metadata on all of the items supported by ArcGIS Online including web maps, web scenes, web apps, layers, uploaded files, and tools. When you publish hosted feature layers, metadata associated with the data is made available with the layer.

Metadata can be created and edited using a web-based editor and viewed as HTML in a separate browser tab. Metadata is viewed with the style selected by the organization. Currently, organizations choose one metadata style for creating, editing, and viewing metadata. Organizations can change the style without losing the metadata.

The web-based editor uses the ArcGIS metadata format. The fields available for editing in the web editor are determined by the style configured for the organization. The ArcGIS metadata format contains fields that can store all content in all metadata standards supported by ArcGIS.

6.1 Metadata styles, standards and profiles

A metadata style configures the editing and viewing experience of the metadata content. A metadata style is like applying a filter to an item's metadata. The style controls how you view the metadata and also the pages that appear in the metadata editor. A standards-based metadata style is designed to support a metadata standard or profile. The style determines how metadata is validated for that standard or profile.

The default item page allows you to see and edit a simple set of metadata properties for an item. The information is indexed and searchable and is available to be used by applications across the platform. The information in item details is straightforward and effective, suitable for anyone who doesn't need to adhere to specific metadata standards. When metadata is enabled for your organization, item details properties are synchronized with the item's standards-based metadata.

6.1.1 Metadata styles

The following metadata styles are provided to support different metadata:

- FGDC CSDGM Metadata—This style allows you to view and edit metadata following the FGDC *Content Standard for Digital Geospatial Metadata (CSDGM)* guidelines and validate it using the CSDGM XML DTD.

- INSPIRE Metadata Directive—This style allows you to view and edit a complete ISO 19139 metadata document that adheres to the INSPIRE Implementing Rules and validate it using the ISO 19139 XML Schemas.

- ISO 19139 Metadata Implementation Specification—This style allows you to view and edit a complete metadata document that complies with ISO standard 19139, *Geographic information — Metadata — XML schema implementation*, and validate it using the standard's XML Schemas. Use this style to create metadata that complies with ISO standard 19115, *Geographic information — Metadata*.

- ISO 19139 Metadata Implementation Specification GML3.2—This style is identical to the one above, except the files use the GML 3.2 namespace, and therefore can be validated with versions of the ISO 19139 XML Schemas that reference the GML 3.2 namespace. For example, use this style if you plan to validate the metadata files using the NOAA NCDDC XML Schemas.

- North America Profile of ISO 19115 2003—This style allows you to view and edit a complete metadata document that complies with *North American Profile of ISO 19115:2003 – Geographic information Metadata*, and validate it using the ISO 19139 XML Schemas.

6.1.2 Metadata standards and profiles

A metadata standard is a document identifying content that should be provided to describe geospatial resources such as maps, map services, vector data, imagery, and even nonspatial resources such as tables and tools that are relevant to your spatial work. A metadata standard may also provide an XML schema describing the format in which the content should be stored. Typically, a standard XML format is defined using XML Schema or document type definition (DTD). Standards are typically ratified by national or international standards bodies.

Many geospatial metadata standards are produced by ISO committees including ISO 19115 *Geographic Information—Metadata* and ISO 19119 *Geographic Information—Metadata—Services*, which are content standards. In contrast, ISO 19139 *Geographic Information—Metadata—Implementation Specification* provides a set of XML Schemas that define the XML format in which ISO 19115 and ISO 19119 metadata content should be stored.

The Federal Geographic Data Committee (FGDC) created the *Content Standard for Digital Geospatial Metadata (CSDGM)* that has been used in the United States for many years; it is commonly referred to as the FGDC metadata standard. It is another example of a content standard. While there is an accepted

format in which to store this content in XML format, there are also several other file formats that are commonly used to present the information.

A metadata profile is a document that modifies a metadata standard. A profile may reduce the overall number of metadata elements defined by a standard. A profile may further restrict whether a metadata element is optional, making it mandatory where before it was optional; however, a profile cannot make mandatory elements optional. A profile may further restrict the values allowed in a metadata element. Metadata profiles can be adopted by a standards body, agency, or organization in place of a metadata standard. One example of a metadata profile is the *North American Profile of ISO 19115:2003* that has been jointly created and adopted by the United States and Canada.

Whether by choice or by obligation, if you plan to create metadata that follows a standard or profile, obtain a copy of the standard or profile document. For ISO standards, you must purchase the document from ISO or the national organization that participates in ISO, such as ANSI, in the United States. Profiles should be available from the organizations that create them.

6.2   Suggested Metadata format

All iLembe District Municipality GIS deliverables must include the following minimum Metadata: -

- Dataset Name

- Summary and Description

- Credits (Including date of capture/creation)

- Use Limitations (if applicable)

- Contact Details of data capturer/custodian

- Keywords to specific terms or fields used within the dataset

- Absolute spatial accuracy of the data (meters)

Commented [ME20]: Are these specifications included in the GIS specifications included in the bid document on spatial data requirements for a tender?

Commented [LT21R20]: These came from the IDM's GIS Policy.

7 Annexure A: Domain types for Water Pipe Diameters

Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	1	180 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	2	200 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	3	225 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	4	250 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	5	280 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	6	315 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	7	355 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	8	400 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	9	450 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	10	500 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	11	560 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	12	630 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	13	710 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	14	800 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	15	900 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	16	1000 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	17	1200 mm
Water_DiameterBulkWater_HDPE	Bulk Water PipeLine Material HDPE	-100	No data
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	1	160 mm
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	2	200 mm
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	3	250 mm
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	4	315 mm
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	5	355 mm
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	6	400 mm
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	7	450 mm
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	8	500 mm
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	9	560 mm
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	10	630 mm
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	11	560 mm
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	12	630 mm
Water_DiameterBulkWater_uPVC	Bulk Water PipeLine Material uPVC	-100	No data
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	1	160 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	2	200 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	3	225 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	4	250 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	5	315 m
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	6	355 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	7	400 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	8	450 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	9	500 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	10	630 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	11	710 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	12	800 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	13	900 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	14	1000 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	15	1100 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	16	1200 mm
Water_DiameterBulkWater_oPVC	Bulk Water PipeLine Material oPVC	-100	No data

Water_DiameterBulkWater_mPVC	Bulk Water PipeLine Material mPVC	1	177 mm
Water_DiameterBulkWater_mPVC	Bulk Water PipeLine Material mPVC	2	200 mm
Water_DiameterBulkWater_mPVC	Bulk Water PipeLine Material mPVC	3	250 mm
Water_DiameterBulkWater_mPVC	Bulk Water PipeLine Material mPVC	4	315 mm
Water_DiameterBulkWater_mPVC	Bulk Water PipeLine Material mPVC	5	355 mm
Water_DiameterBulkWater_mPVC	Bulk Water PipeLine Material mPVC	6	400 mm
Water_DiameterBulkWater_mPVC	Bulk Water PipeLine Material mPVC	7	450 mm
Water_DiameterBulkWater_mPVC	Bulk Water PipeLine Material mPVC	8	500 mm
Water_DiameterBulkWater_mPVC	Bulk Water PipeLine Material mPVC	9	560 mm
Water_DiameterBulkWater_mPVC	Bulk Water PipeLine Material mPVC	10	630 mm
Water_DiameterBulkWater_mPVC	Bulk Water PipeLine Material mPVC	-100	No data
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	1	368 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	2	445 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	3	533 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	4	616 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	5	699 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	6	787 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	7	870 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	8	946 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	9	1041 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	10	1194 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	11	1365 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	12	1524 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	13	1689 mm
Water_DiameterBulkWater_Reinforced	Bulk Water PipeLine Material Reinforced	-100	No data
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	1	170 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	2	222 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	3	274 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	4	326 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	5	378 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	6	429 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	7	480 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	8	532 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	9	635 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	10	738 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	11	842 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	12	945 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	13	1048 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	14	1152 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	15	1255 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	16	1462 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	17	1565 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	18	1668 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	19	1875 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	20	2082 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	21	2288 mm
Water_DiameterBulkWater_Ductile	Bulk Water PipeLine Material Ductile	-100	No data
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	1	300 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	2	350 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	3	250 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	4	400 mm

Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	5	450 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	6	500 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	7	600 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	8	700 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	9	800 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	10	900 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	11	1000 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	12	1100 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	13	1200 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	14	1300 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	15	1400 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	16	1500 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	17	1600 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	18	1700 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	19	1800 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	20	1900 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	21	2000 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	22	2100 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	23	2200 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	24	2300 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	25	2400 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	26	2500 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	27	2600 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	28	2700 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	29	2800 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	30	2900 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	31	3000 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	32	3100 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	33	3200 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	34	3300 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	35	3400 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	36	3500 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	37	3600 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	38	3700 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	39	3800 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	40	3900 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	41	4000 mm
Water_DiameterBulkWater_GRP	Bulk Water PipeLine Material GRP	-100	No data
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	1	200 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	2	250 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	3	300 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	4	350 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	5	400 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	6	450 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	7	500 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	8	550 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	9	600 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	10	650 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	11	700 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	12	750 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	13	800 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	14	850 mm

Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	15	900 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	16	950 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	17	1000 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	18	1050 mm
Water_DiameterBulkWater_SANS719	Bulk Water PipeLine Material SANS719	-100	No data
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	1	219.1 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	2	273.1 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	3	323.9 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	4	355.6 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	5	406.4 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	6	457 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	7	508 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	8	610 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	9	660 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	10	711 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	11	762 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	12	813 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	13	864 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	14	914 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	15	965 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	16	1016 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	17	1067 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	18	1118 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	19	1168 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	20	1219 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	21	1321 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	22	1422 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	23	1524 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	24	1626 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	25	1727 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	26	1829 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	27	1930 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	28	2032 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	29	2134 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	30	2286 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	31	2337 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	32	2450 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	33	2540 mm
Water_DiameterBulkWater_SANS1431	Bulk Water PipeLine Material SANS1431	-100	No data
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	1	219.1 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	2	273.1 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	3	323.9 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	4	355.6 mm

Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	5	406.4 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	6	457 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	7	508 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	8	610 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	9	660 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	10	711 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	11	762 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	12	813 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	13	864 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	14	914 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	15	965 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	16	1016 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	17	1067 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	18	1118 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	19	1168 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	20	1219 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	21	1321 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	22	1422 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	23	1524 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	24	1626 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	25	1727 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	26	1829 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	27	1930 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	28	2032 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	29	2134 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	30	2286 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	31	2337 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	32	2450 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	33	2540 mm
Water_DiameterBulkWater_API5L	Bulk Water PipeLine Material API5L	-100	No data
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	1	16 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	2	20 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	3	25 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	4	32 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	5	40 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	6	50 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	7	63 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	8	75 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	9	90 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	10	110 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	11	125 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	12	140 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	13	160 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	14	180 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	15	900 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	16	1000 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	17	1200 mm
Water_DiameterWaterReticulation_HDPE	Diameter Water Reticulation HDPE	-100	No data
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	1	16 mm
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	2	20 mm
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	3	25 mm

Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	4	32 mm
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	5	40 mm
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	6	50 mm
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	7	63 mm
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	8	75 mm
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	9	90 mm
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	10	110 mm
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	11	125 mm
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	12	140 mm
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	13	160 mm
Water_DiameterWaterReticulation_uPVC	Diameter Water Reticulation uPVC	-100	No data
Water_DiameterWaterReticulation_mPVC	Diameter Water Reticulation mPVC	1	50 mm
Water_DiameterWaterReticulation_mPVC	Diameter Water Reticulation mPVC	2	63 mm
Water_DiameterWaterReticulation_mPVC	Diameter Water Reticulation mPVC	3	75 mm
Water_DiameterWaterReticulation_mPVC	Diameter Water Reticulation mPVC	4	90 mm
Water_DiameterWaterReticulation_mPVC	Diameter Water Reticulation mPVC	5	110 mm
Water_DiameterWaterReticulation_mPVC	Diameter Water Reticulation mPVC	6	122 mm
Water_DiameterWaterReticulation_mPVC	Diameter Water Reticulation mPVC	7	125 mm
Water_DiameterWaterReticulation_mPVC	Diameter Water Reticulation mPVC	8	140 mm
Water_DiameterWaterReticulation_mPVC	Diameter Water Reticulation mPVC	9	160 mm
Water_DiameterWaterReticulation_mPVC	Diameter Water Reticulation mPVC	10	177 mm
Water_DiameterWaterReticulation_mPVC	Diameter Water Reticulation mPVC	-100	No data
Water_DiameterWaterReticulation_oPVC	Diameter Water Reticulation oPVC	1	90 mm
Water_DiameterWaterReticulation_oPVC	Diameter Water Reticulation oPVC	2	110 mm
Water_DiameterWaterReticulation_oPVC	Diameter Water Reticulation oPVC	3	125 mm
Water_DiameterWaterReticulation_oPVC	Diameter Water Reticulation oPVC	4	140 mm
Water_DiameterWaterReticulation_oPVC	Diameter Water Reticulation oPVC	5	160 m
Water_DiameterWaterReticulation_oPVC	Diameter Water Reticulation oPVC	6	160 mm
Water_DiameterWaterReticulation_oPVC	Diameter Water Reticulation oPVC	-100	No data
Water_DiameterWaterReticulatio_Ductile	Diameter Water Reticulation Ductile	1	98 mm
Water_DiameterWaterReticulatio_Ductile	Diameter Water Reticulation Ductile	2	118 mm
Water_DiameterWaterReticulatio_Ductile	Diameter Water Reticulation Ductile	3	144 mm
Water_DiameterWaterReticulatio_Ductile	Diameter Water Reticulation Ductile	4	170 mm
Water_DiameterWaterReticulatio_Ductile	Diameter Water Reticulation Ductile	5	378 mm
Water_DiameterWaterReticulatio_Ductile	Diameter Water Reticulation Ductile	-100	No data
Water_DiameterWaterReticulation_SANS62	Diameter Water Reticulation SANS62	1	15 mm
Water_DiameterWaterReticulation_SANS62	Diameter Water Reticulation SANS63	2	20 mm
Water_DiameterWaterReticulation_SANS62	Diameter Water Reticulation SANS64	3	25 mm
Water_DiameterWaterReticulation_SANS62	Diameter Water Reticulation SANS65	4	32 mm
Water_DiameterWaterReticulation_SANS62	Diameter Water Reticulation SANS66	5	40 mm
Water_DiameterWaterReticulation_SANS62	Diameter Water Reticulation SANS67	6	50 mm
Water_DiameterWaterReticulation_SANS62	Diameter Water Reticulation SANS68	7	65 mm
Water_DiameterWaterReticulation_SANS62	Diameter Water Reticulation SANS69	8	80 mm
Water_DiameterWaterReticulation_SANS62	Diameter Water Reticulation SANS70	9	100 mm
Water_DiameterWaterReticulation_SANS62	Diameter Water Reticulation SANS71	10	125 mm
Water_DiameterWaterReticulation_SANS62	Diameter Water Reticulation SANS72	11	150 mm
Water_DiameterWaterReticulation_SANS62	Diameter Water Reticulation SANS72	-100	No data
Water_DiameterWaterReticulation_Polypropylene	Diameter Water Reticulation Polypropylene	1	20 mm

Water_DiameterWaterReticulation_Polypropylene	Diameter Water Reticulation Polypropylene	2	25 mm
Water_DiameterWaterReticulation_Polypropylene	Diameter Water Reticulation Polypropylene	3	32 mm
Water_DiameterWaterReticulation_Polypropylene	Diameter Water Reticulation Polypropylene	4	75 mm
Water_DiameterWaterReticulation_Polypropylene	Diameter Water Reticulation Polypropylene	5	90 mm
Water_DiameterWaterReticulation_Polypropylene	Diameter Water Reticulation Polypropylene	6	110 mm
Water_DiameterWaterReticulation_Polypropylene	Diameter Water Reticulation Polypropylene	-100	**No data**

8   Annexure B: Operations and Procedures Policy, iLembe District Municipality.