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Groundwater Reserve Determination Study in the Mhlathuze Catchment

Definitions
Appendices
Capacity Building

INSTITUTE FOR GROUNDWATER STUDIES

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DEFINITIONS

LIST OF GEOHYDROLOGICAL AND RESERVE TERMINOLOGY

ABSTRACTION: the removal of water from a resource, e.g. pumping groundwater from an aquifer.

ALLUVIAL AQUIFER: an aquifer formed by unconsolidated material deposited by water, typically occurring adjacent to river channels and in buried or palaeochannels.

ALLUVIUM: a general term for unconsolidated deposits of inorganic materials (clay, silt, sand, gravel, boulders) deposited by flowing water.

AQUATIC: associated with and dependent on water, e.g. aquatic vegetation.

AQUATIC ECOSYSTEMS: not defined by the National Water Act (Act No. 36 of 1998), but defined elsewhere as the *abiotic* (physical and chemical) and *biotic* components, habitats and ecological processes contained within rivers and their riparian zones and reservoirs, lakes, wetlands and fringing vegetation.

AQUIFER: a geological formation, which has structures or textures that hold water or permit appreciable water movement through them [from National Water Act (Act No. 36 of 1998)].

AQUIFER SYSTEM: a heterogeneous body of intercalated permeable and less permeable material that acts as a water-yielding hydraulic unit of regional extent.

AQUIFER TESTING: the process whereby an aquifer is subjected to pumping from a borehole under controlled test conditions in order to determine the hydraulic parameters of the groundwater system through its response to the stress of abstraction.

ARTESIAN BOREHOLE: commonly used to describe a flowing borehole, where the piezometric level is at an elevation higher than ground level.

AVAILABLE DRAWDOWN: the height of water above the depth at which the pump is set in a borehole at the time of water level measurement (m).

BANK STORAGE: water that percolates laterally from a river in flood into the adjacent geological material, some of which may flow back into the river during low-flow conditions.

BASEFLOW: sustained low flow in a river during dry or fair weather conditions, but not necessarily all contributed by groundwater; includes contributions from delayed interflow and groundwater discharge.

BASIC HUMAN NEED: the least amount of water required to satisfy basic water requirements; this is currently set at 25 l/cap·d.

BOREHOLE: includes a well, excavation, or any other artificially constructed or improved groundwater cavity that can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and

information on water in an aquifer; or recharging an aquifer [from National Water Act (Act No. 36 of 1998)].

BRACKISH: water that contains between 1 000 and 10 000 mg/ℓ of dissolved solids.

CATCHMENT: the area from which any rainfall will drain into the watercourse, contributing to the run-off at a particular point in a river system; synonymous with the term *river basin*.

COMPREHENSIVE RESERVE ASSESSMENT: an assessment of the Reserve based on detailed data and observation; may include numerical modelling; also referred to as a full Reserve assessment.

CONE OF DEPRESSION: the cone-shaped area around a borehole that results from lowering the water table or piezometric surface by abstraction.

CONFINED AQUIFER: an aquifer overlain by a confining layer of significantly lower hydraulic conductivity in which groundwater is under greater pressure than that of the atmosphere; also known as an artesian aquifer.

CONJUNCTIVE USE: combined use of surface and groundwater.

DESIRED ECOLOGICAL STATUS: the future desired status of groundwater within the resource unit as used in setting the groundwater component of the ecological Reserve.

DISCONNECTED STREAM: a stream detached from and not in hydrological contact with the groundwater system below; a special case of an influent stream; also referred to as a detached stream.

DISSOLVED SOLIDS: minerals and organic matter dissolved in water.

DRAWDOWN: the difference between the observed groundwater level during pumping and the non-pumping or rest groundwater level in a borehole.

ECOLOGICAL WATER REQUIREMENT: This term is widely used for both rivers and estuaries when referring to both quantity and quality requirements. When referring to river quantity, the term *Inflow Stream Requirement* is used.

ECOREGIONS: regions within which there is a relative similarity in the mosaic of ecosystems and ecosystem components (*biotic* and *abiotic*, *aquatic* and terrestrial).

ECOSYSTEM: an organic community of plants, animals and bacteria and the physical and chemical environment they inhabit.

EPHEMERAL RIVERS: these rivers are generally storm-event driven and flow occurs less than 20% of the time; these rivers have a limited (if any) baseflow component with no groundwater discharge.

ESTUARY: a partially or fully enclosed body of water, that is open to the sea permanently or periodically, and within which the sea water can be diluted, to an extent that is measurable, with fresh water drained from the land [from National Water Act (Act No. 36 of 1998)].

EVAPOTRANSPIRATION: the loss of moisture from the combined effects of direct evaporation from land and sea and transpiration from vegetation.

EXPLOITATION POTENTIAL: the rate at which groundwater can be withdrawn from a catchment without causing any detrimental impacts.

FAULT: a zone of displacement in rock formations resulting from forces of tension or compression in the earth's crust.

FORMATION: a general term to describe a sequence of rock layers.

FRACTURE: cracks, joints or breaks in the rock that can enhance water movement.

FRACTURED AQUIFER: an aquifer that owes its water-bearing properties to fracturing caused by folding and faulting; see *secondary aquifer*.

GEOHYDROLOGY: the study of the properties, circulation and distribution of groundwater; in practice used interchangeably with hydrogeology; but in theory *hydrogeology* is the study of geology from the perspective of its role and influence in hydrology, while *geohydrology* is the study of hydrology from the perspective of the influence on geology.

GROUNDWATER: water found in the subsurface in the saturated zone below the water table or piezometric surface, i.e. the water table marks the upper surface of groundwater systems.

GROUNDWATER CONTRIBUTION TO BASEFLOW OR RIVER FLOW: that groundwater that discharges into effluent streams and sustains baseflow.

GROUNDWATER FLOW: the movement of water through openings and pore spaces in rocks below the water table, i.e. in the saturated zone.

GROUNDWATER RESOURCE UNIT: a groundwater body that has been delineated or grouped into a single significant water resource based on one or more characteristics that are similar across that unit; also referred to as a *groundwater unit*.

HARVEST POTENTIAL: maximum amount of groundwater that can be abstracted per square kilometer per annum without depleting the aquifers.

HYDRAULIC CONDUCTIVITY: measure of the ease with which water will pass through earth material; defined as the rate of flow through a cross-section of one square metre under a unit hydraulic gradient at right angles to the direction of flow (in m/d).

HYDRAULIC GRADIENT: the slope of the water table or piezometric surface. It is a ratio of the change of hydraulic head divided by the distances between the two points of measurement.

HYDROGRAPH: a graphical plot of hydrological measurements over a period of time, e.g. water level, flow, discharge.

INFLUENT RIVER: water is discharged from the river into the groundwater system.

INFLUENT STREAM: a *losing stream* above the water table that discharges into the underlying groundwater system; opposite of *effluent stream*.

INSTREAM FLOW REQUIREMENTS: Also referred to as the "ecological flow component of the Reserve". The flow patterns (magnitude, timing and duration) required to maintain a riverine ecosystem in a particular condition.

INTERFLOW: the rapid flow of water along essentially unsaturated flow paths, water that infiltrates the subsurface and moves both vertically and laterally before discharging into other water bodies.

INTERMITTENT RIVER: conditions range seasonally between discharge from the river into the groundwater system and discharge from the groundwater system into the river; not to be confused with an *ephemeral river*.

LATRINE: a pit used for the disposal of human excreta, particularly prevalent in rural areas.

LITHOLOGY: the physical character of rocks.

LOW FLOW: The low flow component of the flow regime, determined graphically from time series of flows.

MAINTENANCE FLOW: The flow required to meet the requirements of the riverine ecosystem at a particular site and maintain the resource base in a particular condition, or Ecological Class during "normal" climatic years, as opposed to "drought" years.

MAJOR AQUIFER SYSTEM: highly permeable formations, usually with a known or probable presence of significant fracturing; may be highly productive and able to support large abstractions for public supply and other purposes; water quality is generally very good.

MINOR AQUIFER SYSTEM: fractured or potentially fractured rocks that do not have a high primary permeability, or other formations of variable permeability; aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important both for local supplies and supplying base flow for rivers.

PERCHED AQUIFERS: aquifers that contain perched groundwater, i.e. bodies of groundwater separated from an underlying body of groundwater by an unsaturated zone.

PERCHED SPRINGS: springs fed by water in the unsaturated zone and interflow.

PERENNIAL: lasting through a year or several years, i.e. a river that flows all year round or a wetland that remains wet all year round.

PIEZOMETRIC LEVEL: the elevation to which groundwater levels rise in boreholes that penetrate confined or semi-confined aquifers.

PIEZOMETRIC SURFACE: an imaginary surface representing the piezometric pressure or hydraulic head throughout all or part of a confined or semi-confined aquifer; analogous to the *water table* of an *unconfined aquifer.*

POLLUTION: the introduction into the environment of any substance by human action that is, or results in, significant harmful effects to man or the environment.

POTABLE WATER: water that is safe and palatable for human use.

PRESENT ECOLOGICAL CLASS: current status of groundwater within the resource unit as used in setting the groundwater component of the ecological Reserve.

PRISTINE: remaining in a pure or natural state.

QUATERNARY CATCHMENT: a fourth-order catchment in a hierarchal classification system in which a primary catchment is the major unit.

RADIUS OF INFLUENCE: the maximum extent of the *cone of depression*.

RECHARGE: the addition of water to the zone of saturation, either by the downward percolation of precipitation or surface water and/or the lateral migration of groundwater from adjacent aquifers.

RECHARGE AREA: an area over which recharge occurs.

RESERVE: the quantity and quality of water required to supply the basic needs of the people to be supplied with water from that resource, and to protect aquatic ecosystems in order to secure ecologically sustainable development and the use of water resources.

RESOURCE: a substance or item available for use. A natural resource is a resource that man can use, but not manufacture or create.

RESOURCE QUALITY: the quality of all aspects of a water resource, including (a) the quality, pattern, timing, water level and assurance of instream flow, (b) the water quality, including the physical, chemical and biological characteristics of water, (c) the characteristic and condition of the instream and riparian habitat, and (d) the characteristics, condition and distribution of aquatic biota.

RESOURCE QUALITY OBJECTIVE: Resource Quality Objectives are used to put a Classification and Reserve into practice by specifying conditions that will ensure that the Class is not compromised and the Reserve can be met. Resource quality may relate to critical flows, groundwater levels and quality that must be maintained. The objectives are to articulate goals that result from the catchment visioning process, but must be based on DWAF policy statements and methodologies, and aligned with the National Water Resource Strategy.

RESOURCE UNITS: areas of similar physical or ecological properties that is grouped or typed to simplify the Reserve determination process.

REST WATER LEVEL: the groundwater level in a borehole not influenced by abstraction; synonymous with *static water level,* but no groundwater levels are ever truly static, as they continually respond to recharge, discharge and abstraction.

RIPARIAN: area of land directly adjacent to a stream or river, influenced by stream-induced or related processes.

RIVER: a physical channel in which run-off will flow; generally larger than a *stream*, but often used interchangeably.

RUNOFF: all surface and subsurface flow from a catchment, but in practice refers to the flow in a river, i.e. excludes groundwater not discharged into a river.

SAFE YIELD: amount of water that can be withdrawn from an aquifer without producing an undesired effect.

SALINE INTRUSION: replacement of fresh water by saline water in an aquifer, usually as a result of groundwater abstraction.

SANITATION: the treatment and disposal of waste from the human body and grey water generated through household activity.

SATURATED ZONE: the subsurface zone below the water table where interstices are filled with water under pressure greater than that of the atmosphere.

SEASONAL RIVER: these rivers are driven by seasonal rainfall patterns and flow occurs between 20% and 80% of the time. These rivers have a limited baseflow component with little or no groundwater discharge.

SEMI-CONFINED AQUIFER: an aquifer that is partly confined by layers of lower permeability material through which recharge and discharge may occur; also referred to as a *leaky aquifer*.

SIGNIFICANT WATER RESOURCES: used but not defined by the National Water Act (Act 36 of 1998); relates to the size of the water resource rather than its importance; a resource is deemed significant if it is large enough to warrant its own Reserve determination.

SOIL: the usually thin upper surface layer of the earth's crust, comprising living organisms, organic matter, decomposed rock or unconsolidated sediments, water and gases with properties attributable to the interaction of its parent material, time, climate, fauna and flora.

SOLE SOURCE AQUIFERS: an aquifer that supplies 50% or more of the domestic water for a given area, and for which there are no reasonably available alternative water sources, should the aquifer be impacted upon or depleted.

SPECIFIC YIELD: ratio of the volume of water that a given mass of saturated rock or soil will yield by gravity from that mass.

SPRING: a point where groundwater emerges, usually as a result of topographical, lithological or structural controls.

STATIC WATER LEVEL: see *rest water level*

STORAGE COEFFICIENT: the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

STORMFLOW: increased run-off in a river or stream associated with a particular rainfall event or storm; includes contributions from *channel precipitation*, *quickflow* and rapid *interflow*.

STREAM: a small narrow river; often used interchangeably with *river*.

STRESSED AQUIFER: not defined by the National Water Act (Act No. 36 of 1998), but using the stress index presented in this manual, an aquifer is said to be stressed when at least 65% of estimated recharge is abstracted from that aquifer.

SURFACE RUN-OFF: that part of the total run-off that travels over the ground surface to reach a stream or river channel.

TRANSMISSIVITY: the rate at which a volume of water is transmitted through a unit width of aquifer under a unit hydraulic head (m^2/d); product of the thickness and average hydraulic conductivity of an aquifer.

UNCONFINED AQUIFER: an aquifer with no confining layer between the water table and the ground surface where the water table is free to fluctuate.

UNSATURATED ZONE: that part of the geological stratum above the water table where interstices and voids contain a combination of air and water; synonymous with *zone of aeration* or *vadose zone*.

VULNERABILITY: the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer.

WATER TABLE: the upper surface of the saturated zone of an unconfined aquifer at which pore pressure is at atmospheric pressure, the depth to which may fluctuate seasonally.

WELL FIELD: a group of boreholes in a particular area usually used for groundwater abstraction purposes.

WETLAND: land that is transitionary between terrestrial and aquatic systems, where the *water table* is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated *soil* [from National Water Act (Act No. 36 of 1998)].

APPENDICES

APPENDIX A: BAYESIAN INTERPOLATION

Water levels were generated across the study area using interpolation of existing data. The interpolation technique used is referred to as Bayesian interpolation where water levels are correlated with the surface topography. All available levels were plotted against the topography in **Figure A1**. The results indicate a very good regional correlation of 98% between the data sets. Therefore, Bayesian interpolation is a valid technique to generate water levels for the area. As groundwater levels follow topography it can be assumed that groundwater flow takes place under unconfined and semi-confined conditions.

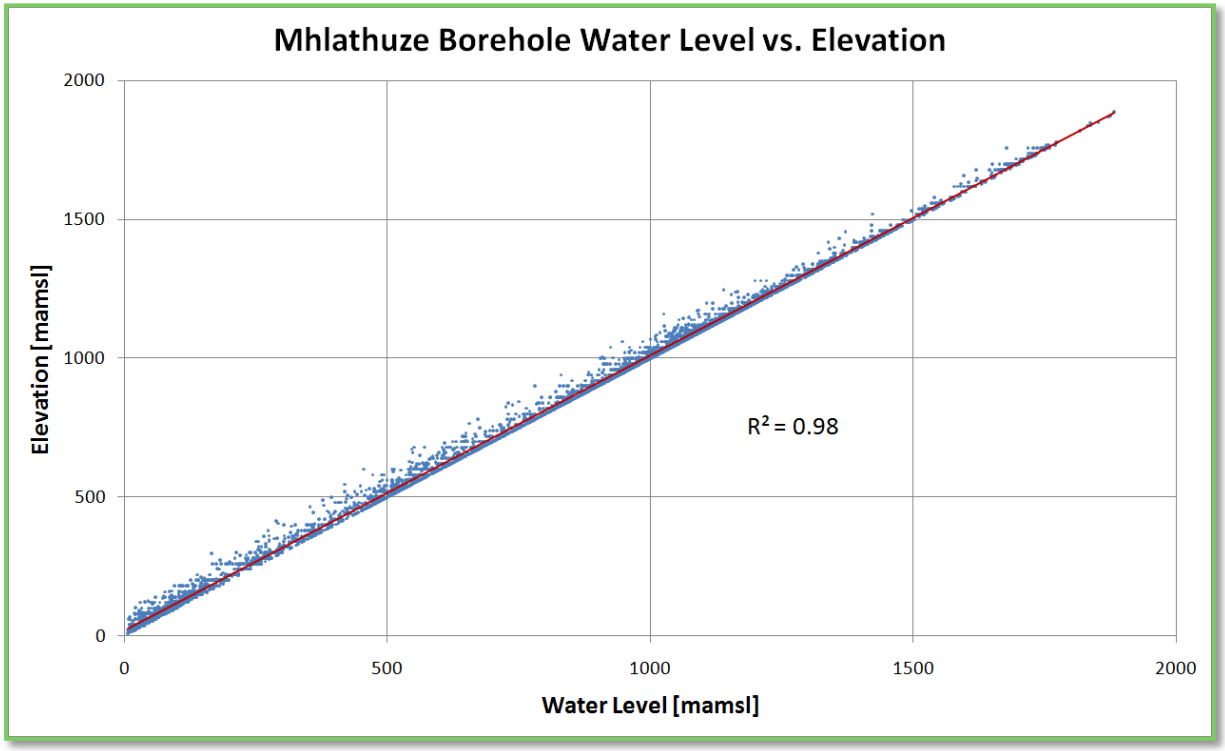


FIGURE A 1: CORRELATION OF TOPOGRAPHY VERSUS GROUNDWATER LEVELS

APPENDIX B: WATER LEVEL HISTOGRAMS

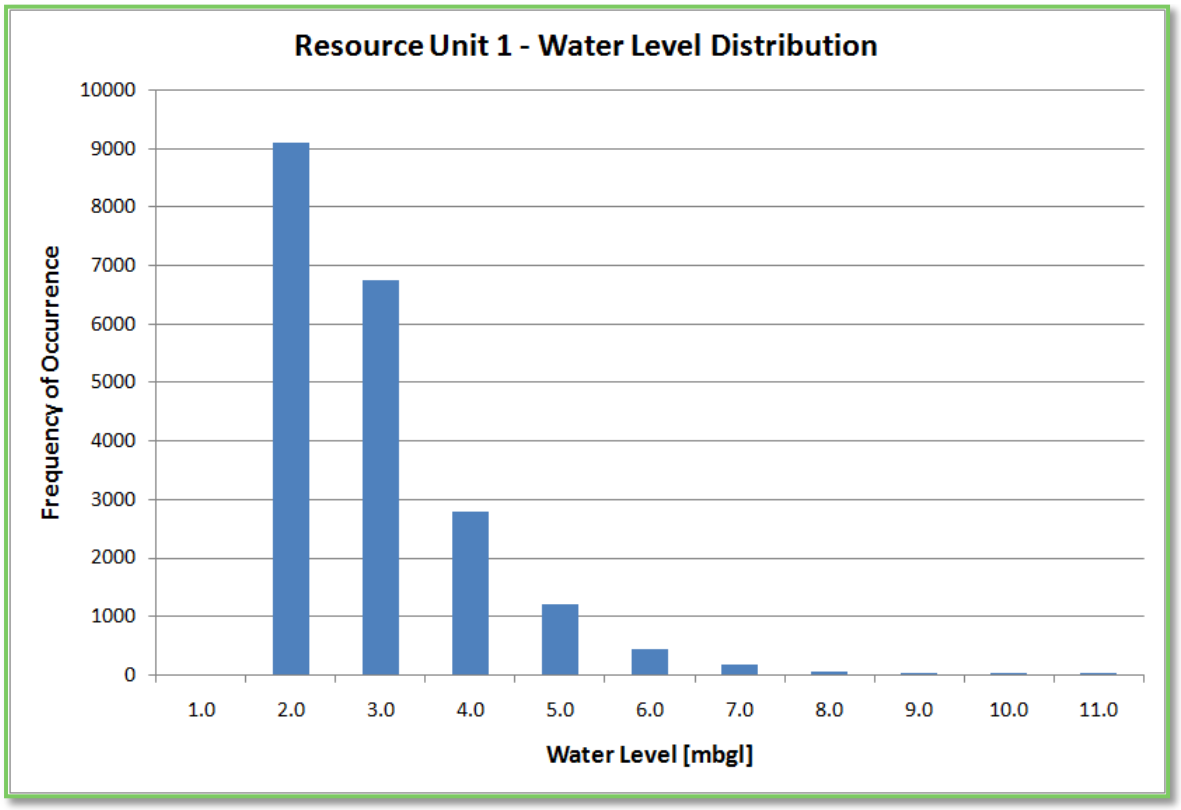


FIGURE B 1: WATER LEVEL HISTOGRAM FOR RU1

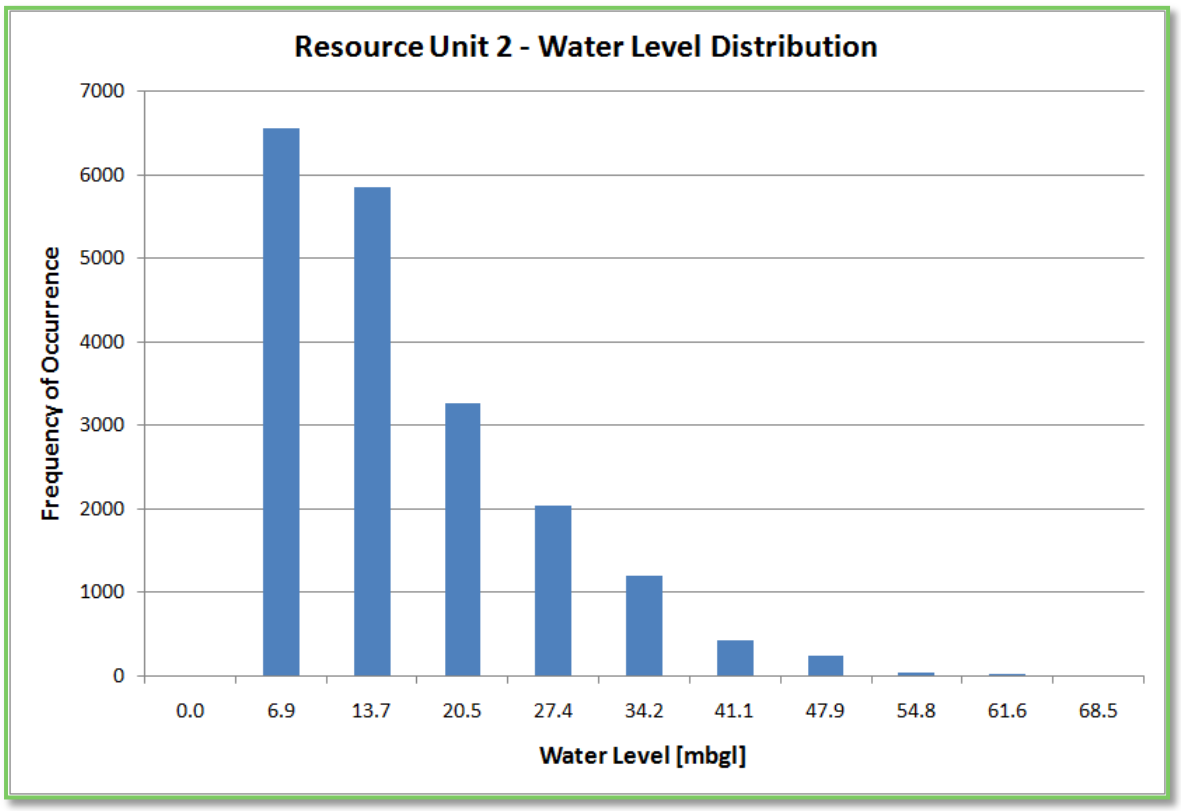


FIGURE B 2: WATER LEVEL HISTOGRAM FOR RU2

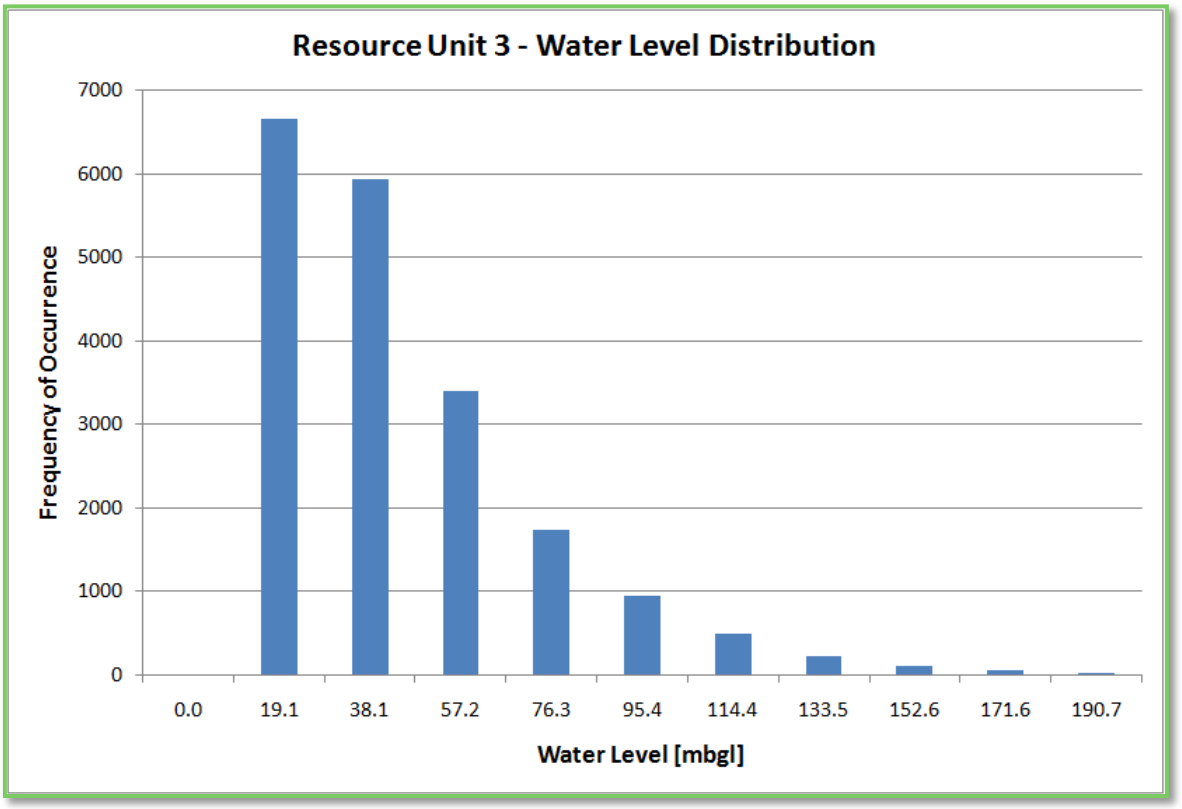


FIGURE B 3: WATER LEVEL HISTOGRAM FOR RU3

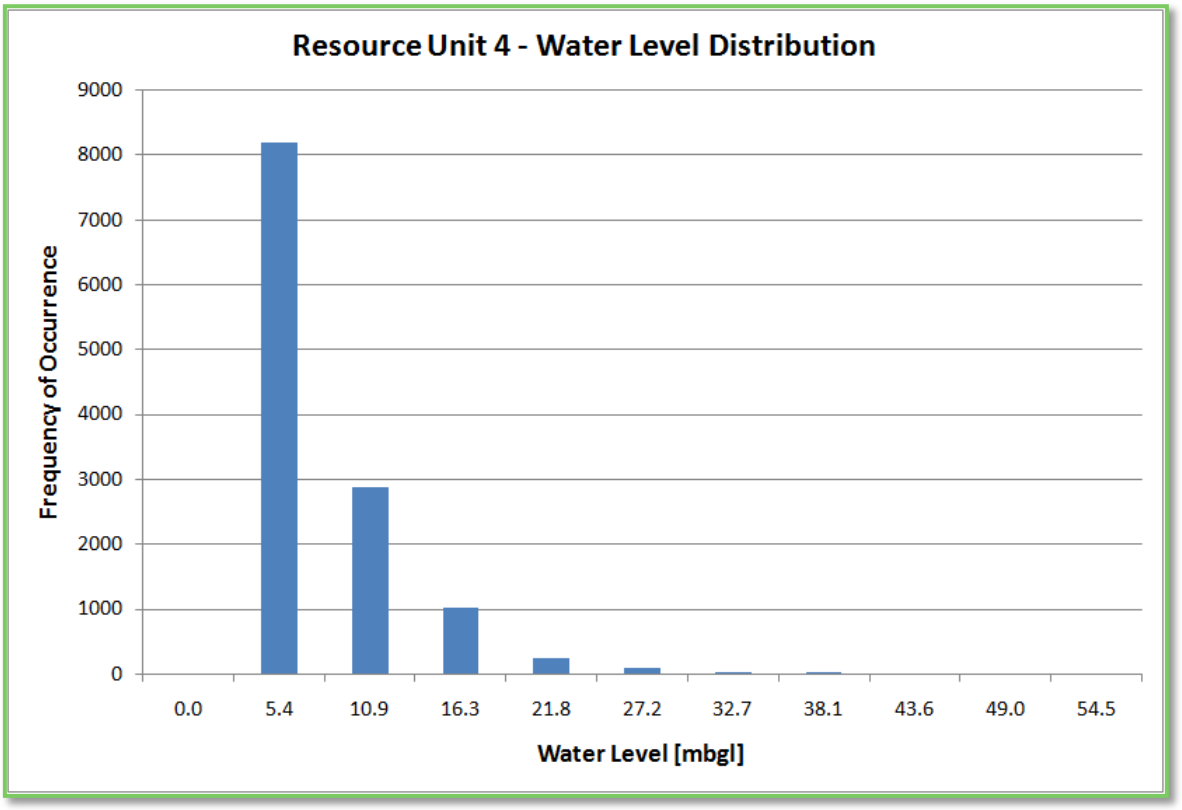


FIGURE B 4: WATER LEVEL HISTOGRAM FOR RU4

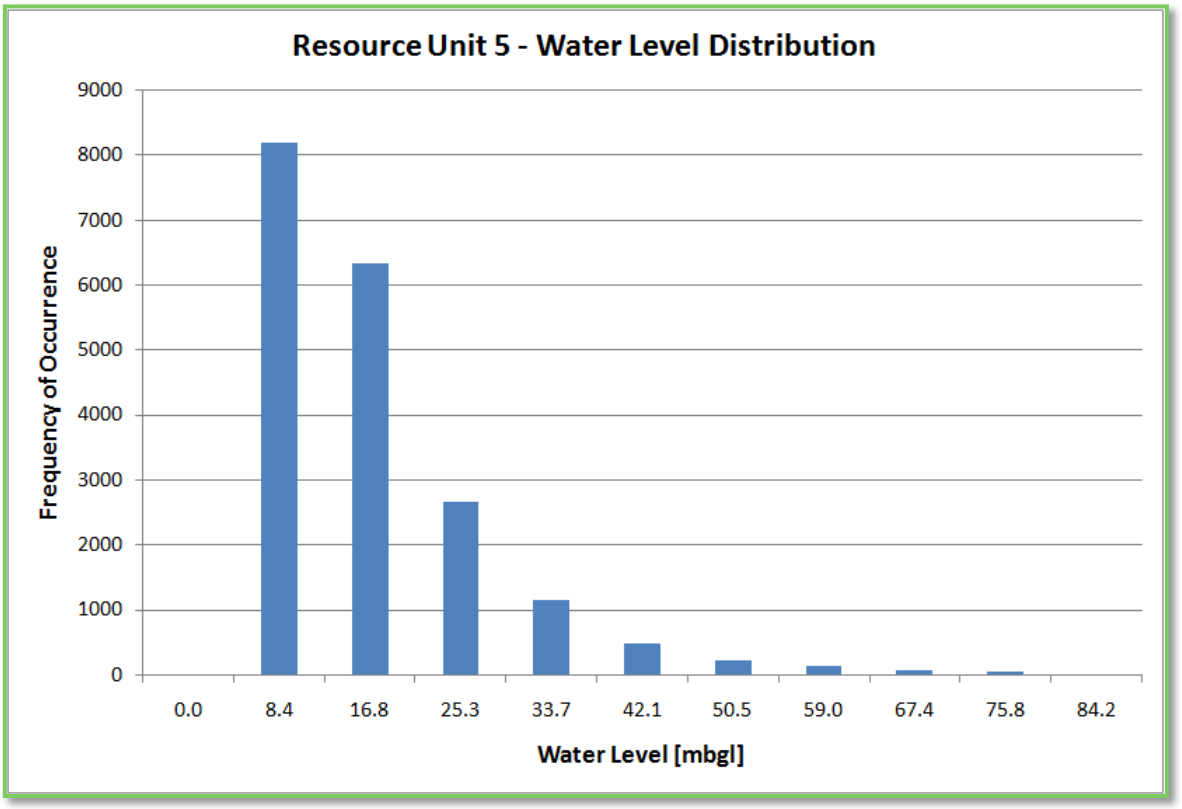


FIGURE B 5: WATER LEVEL HISTOGRAM FOR RU5

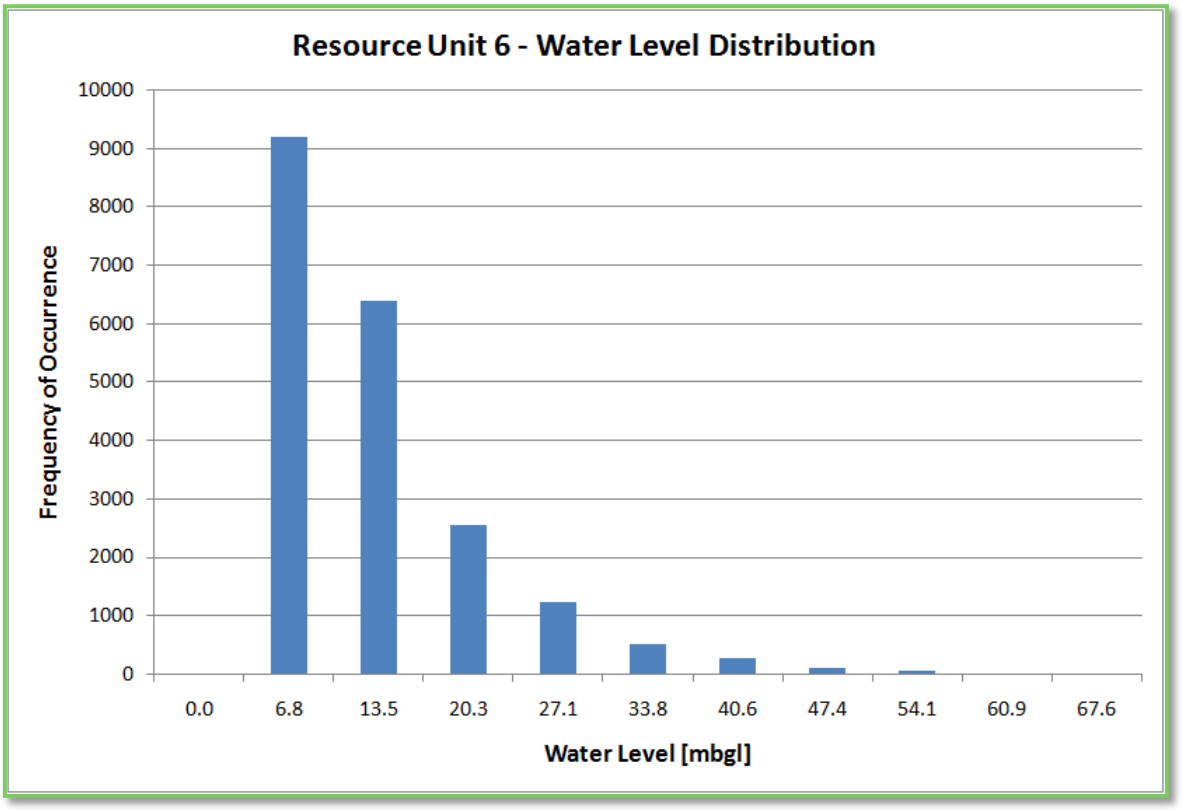


FIGURE B 6: WATER LEVEL HISTOGRAM FOR RU6

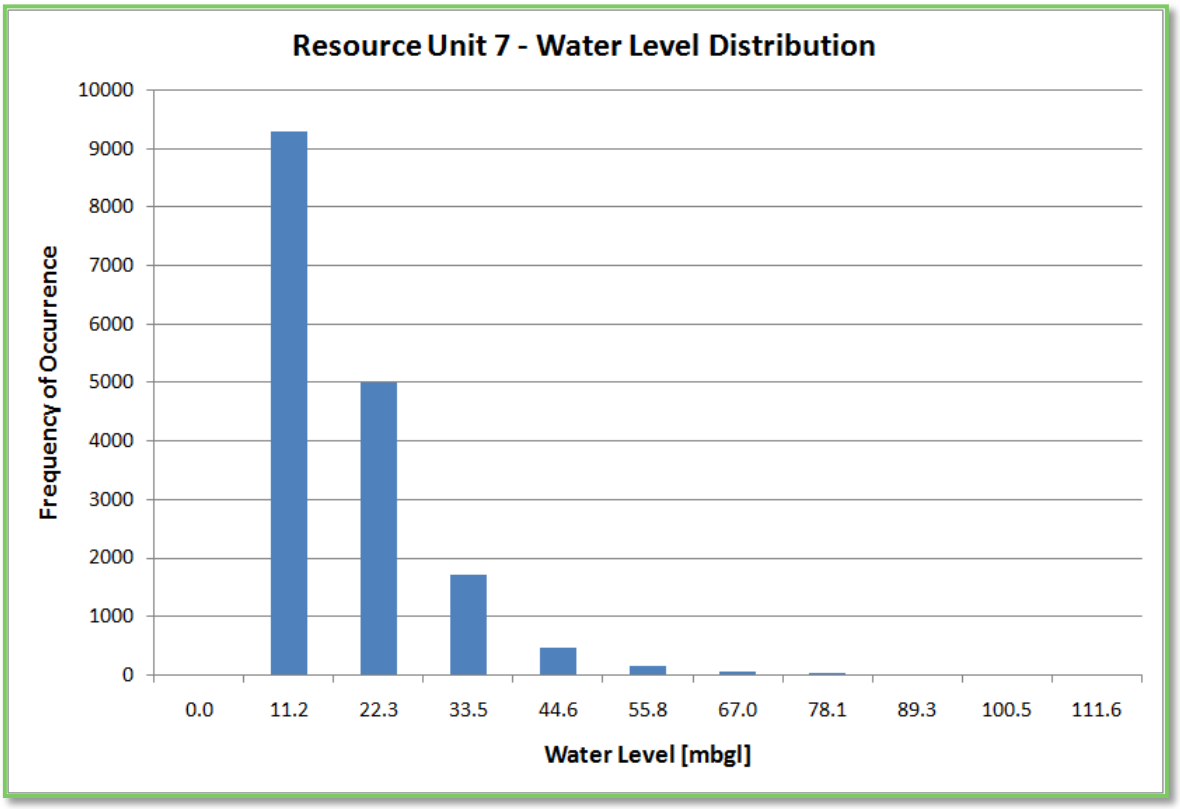
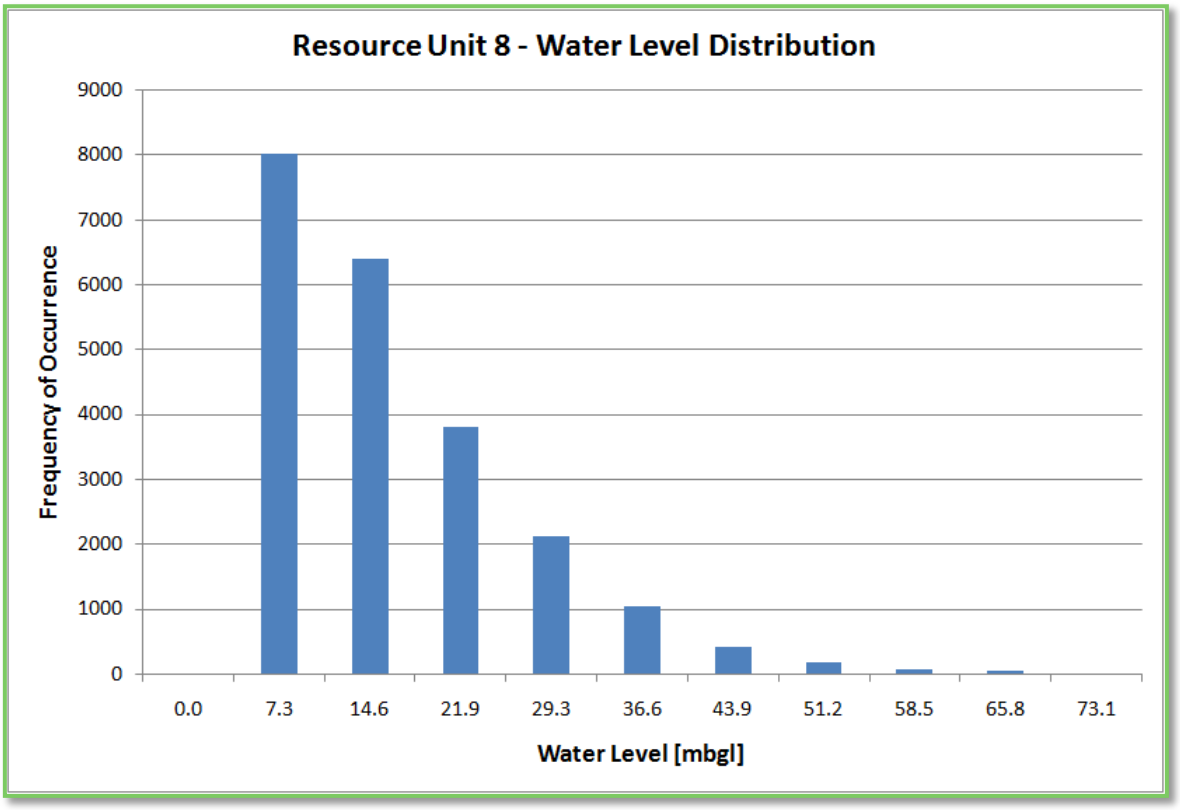


FIGURE B 7: WATER LEVEL HISTOGRAM FOR RU7



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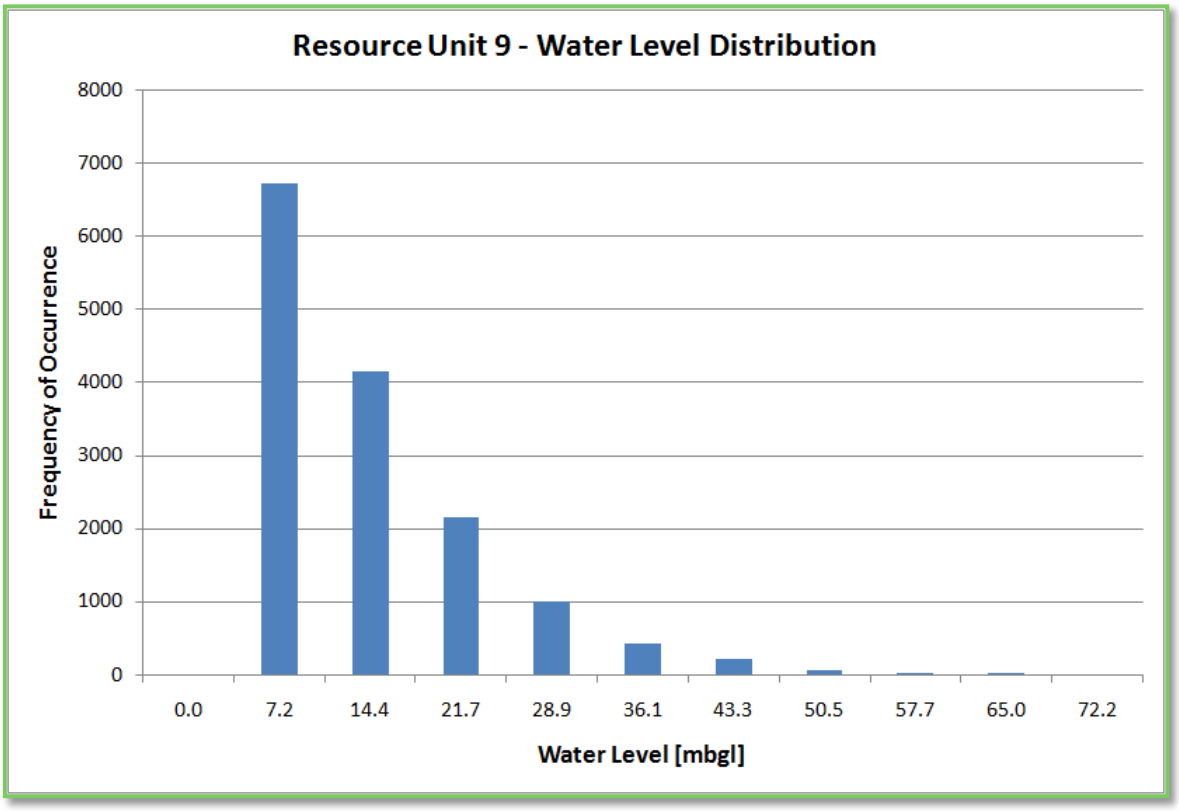


FIGURE B 9: WATER LEVEL HISTOGRAM FOR RU9

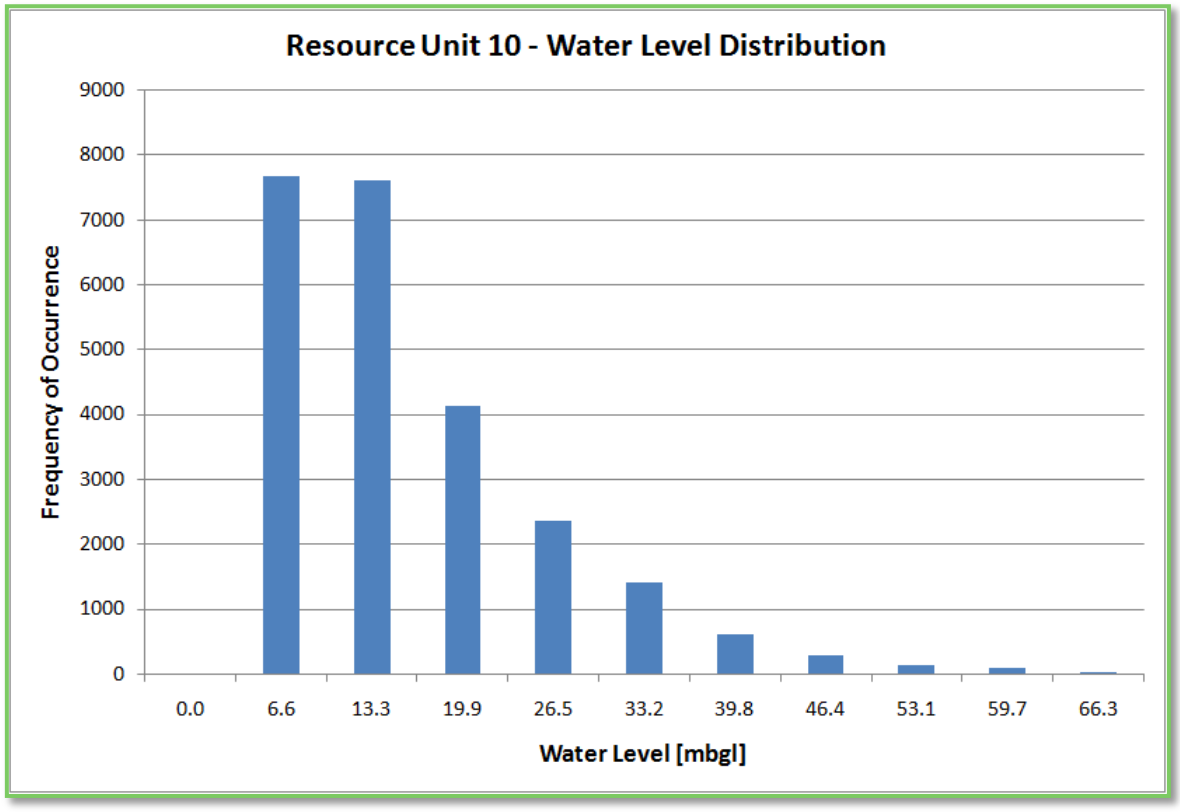
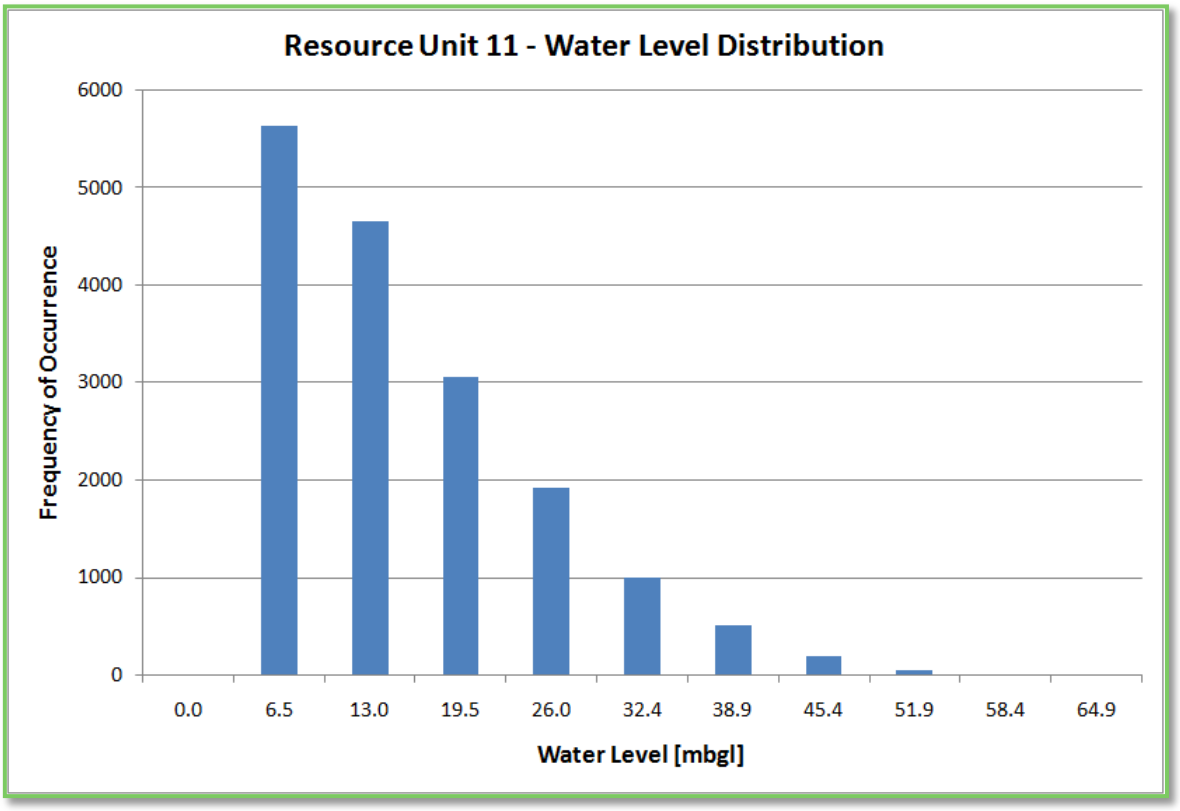


FIGURE B 10: WATER LEVEL HISTOGRAM FOR RU10



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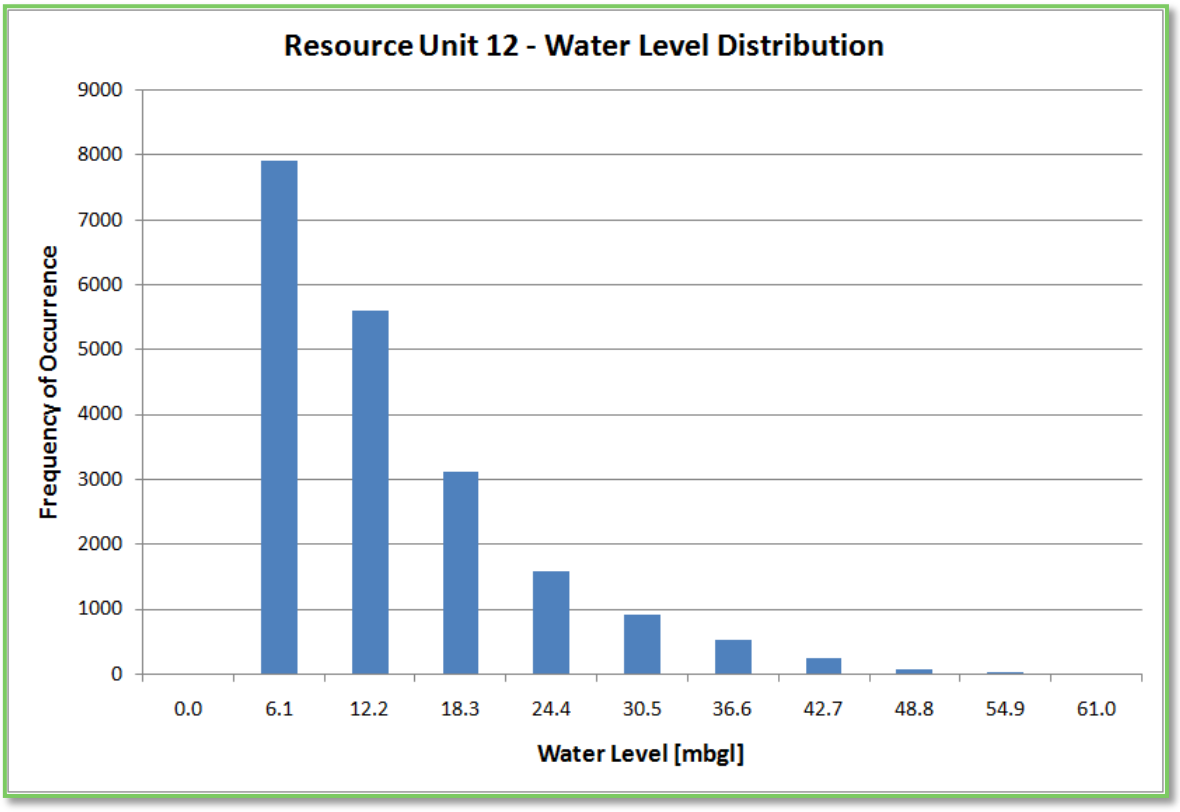

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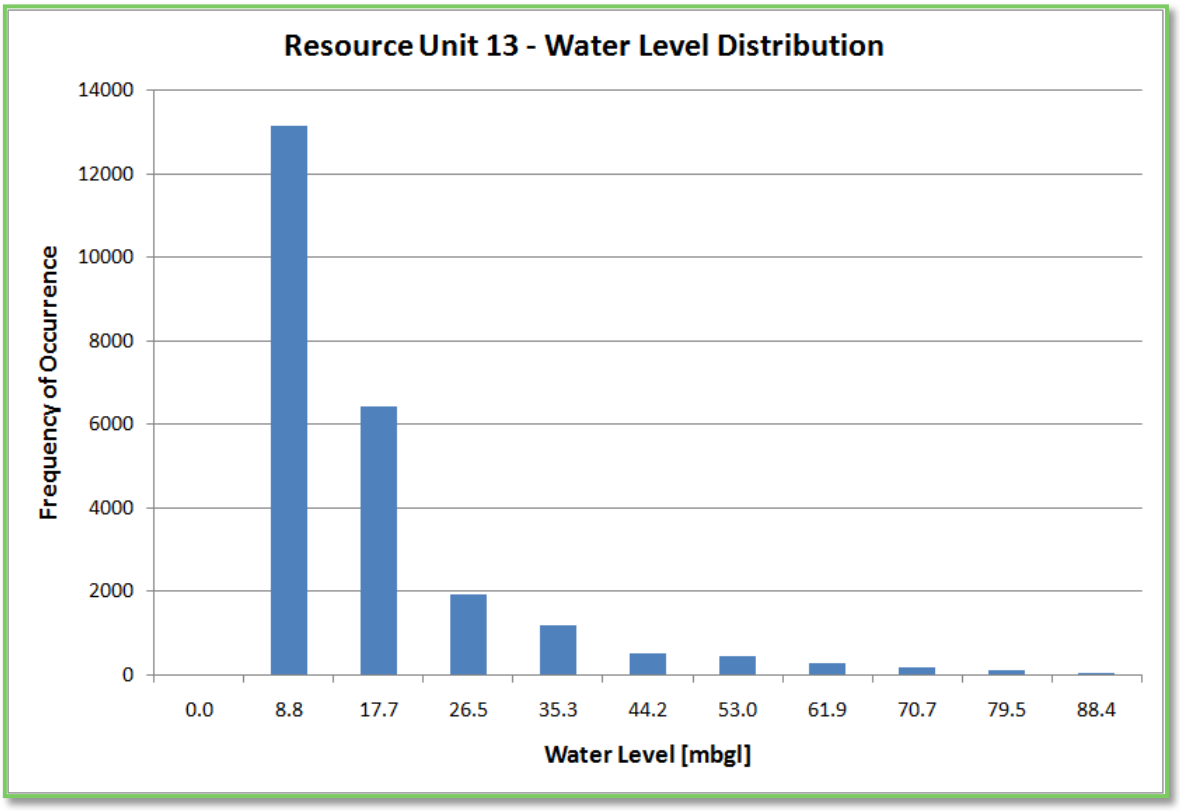

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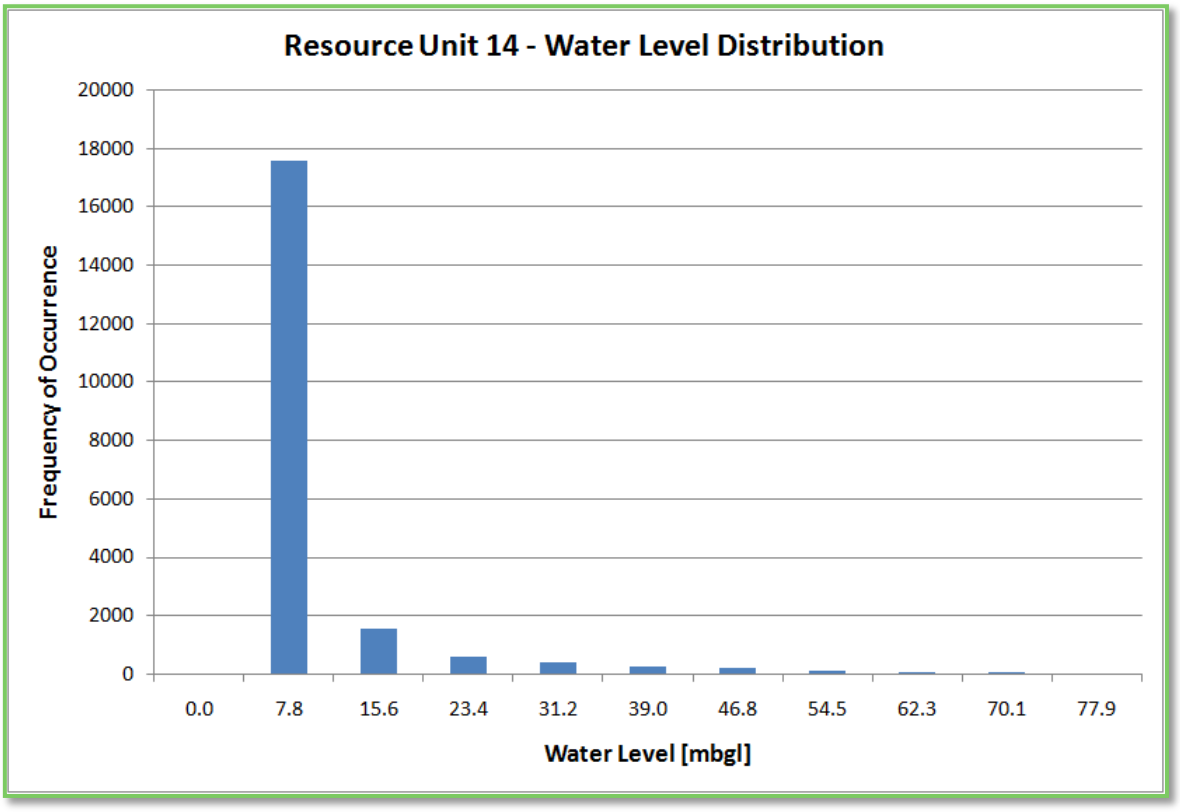

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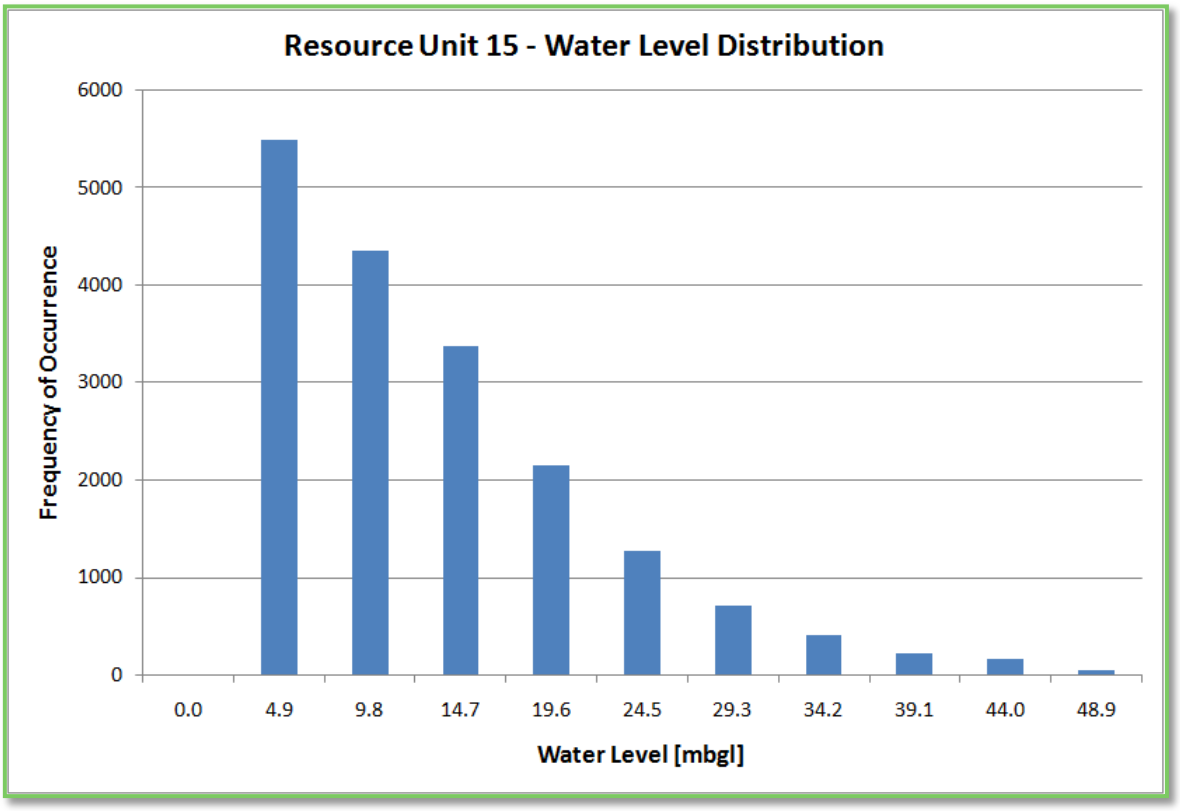

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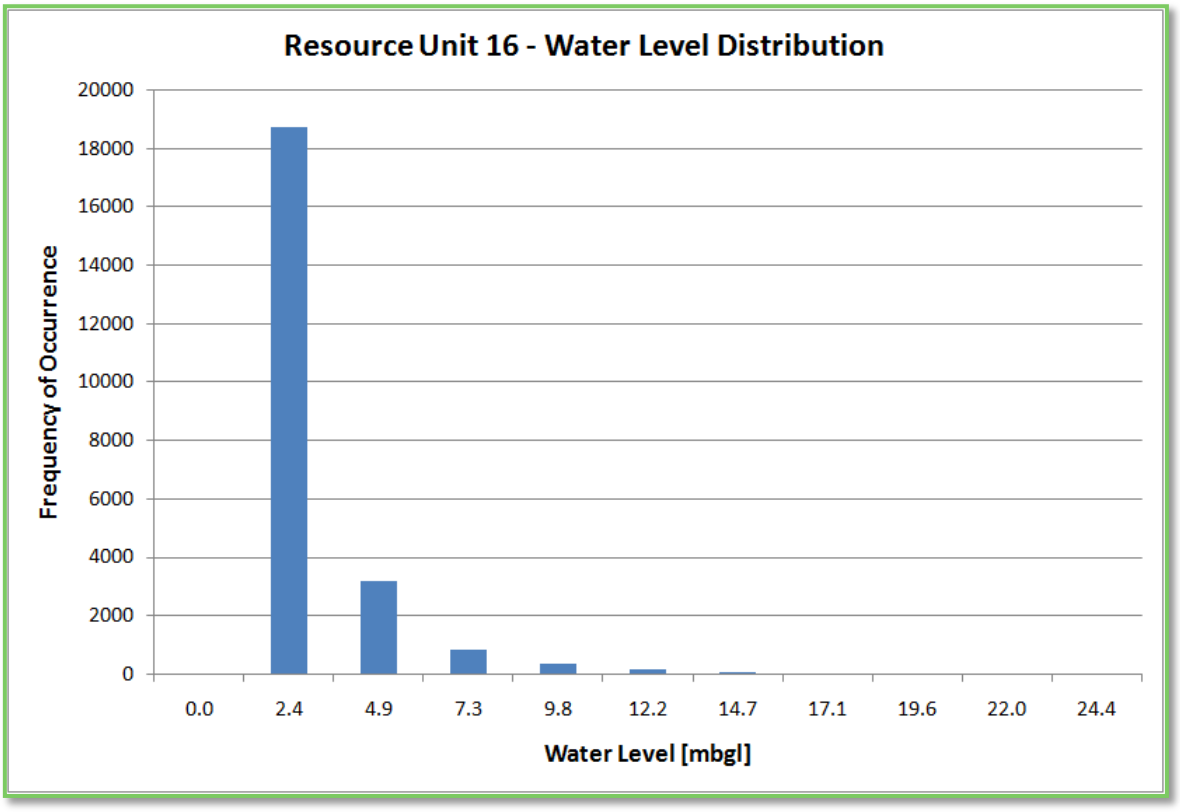

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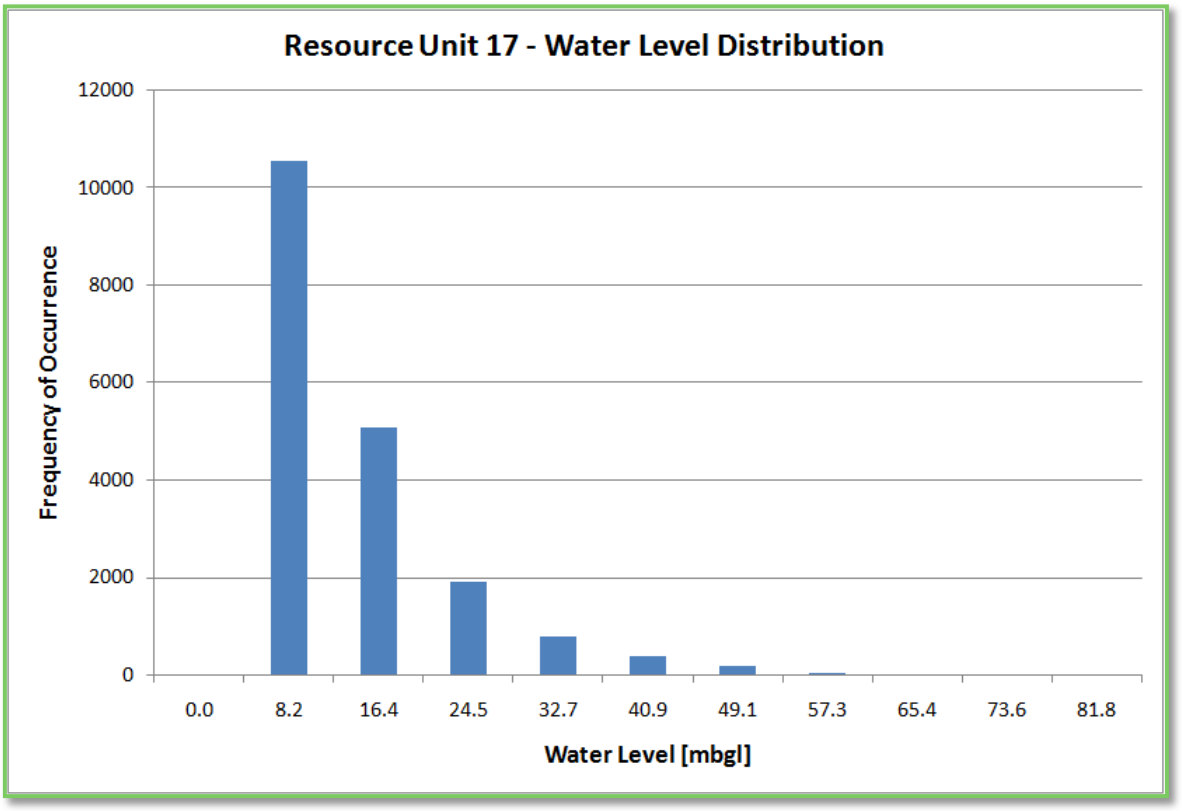
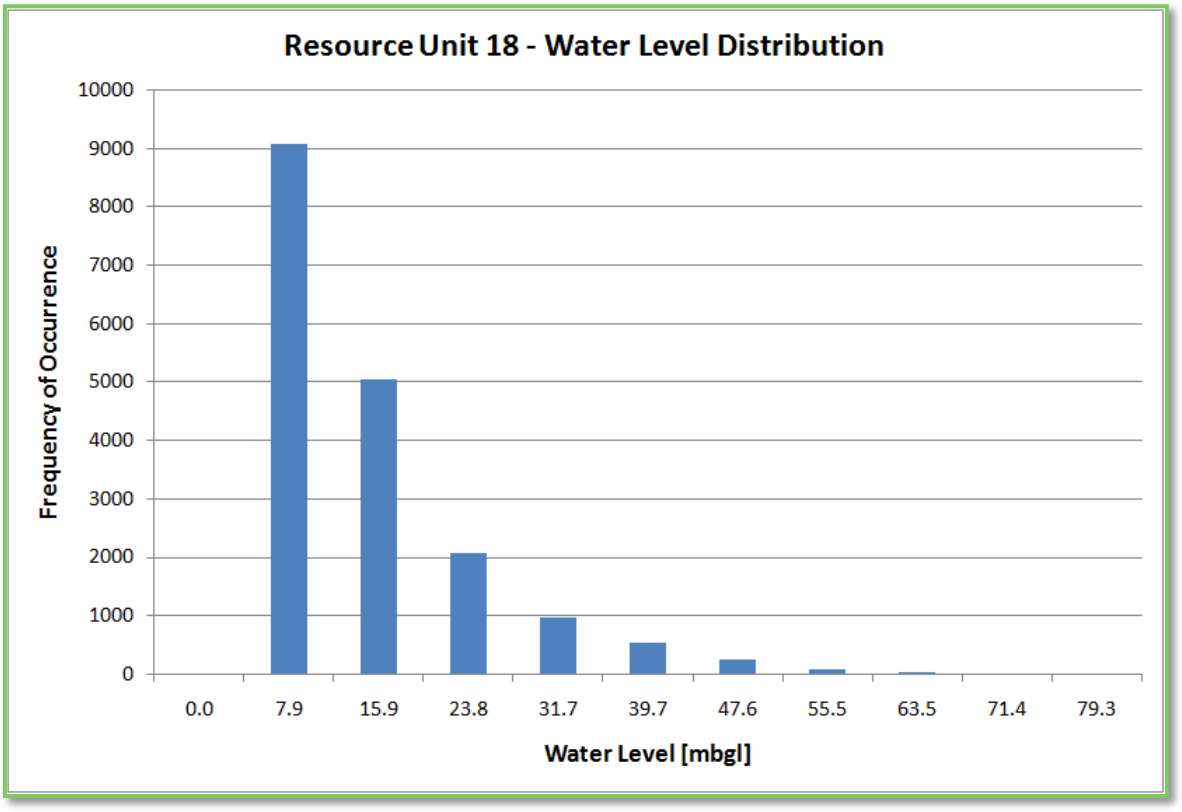


FIGURE B 17: WATER LEVEL HISTOGRAM FOR RU17



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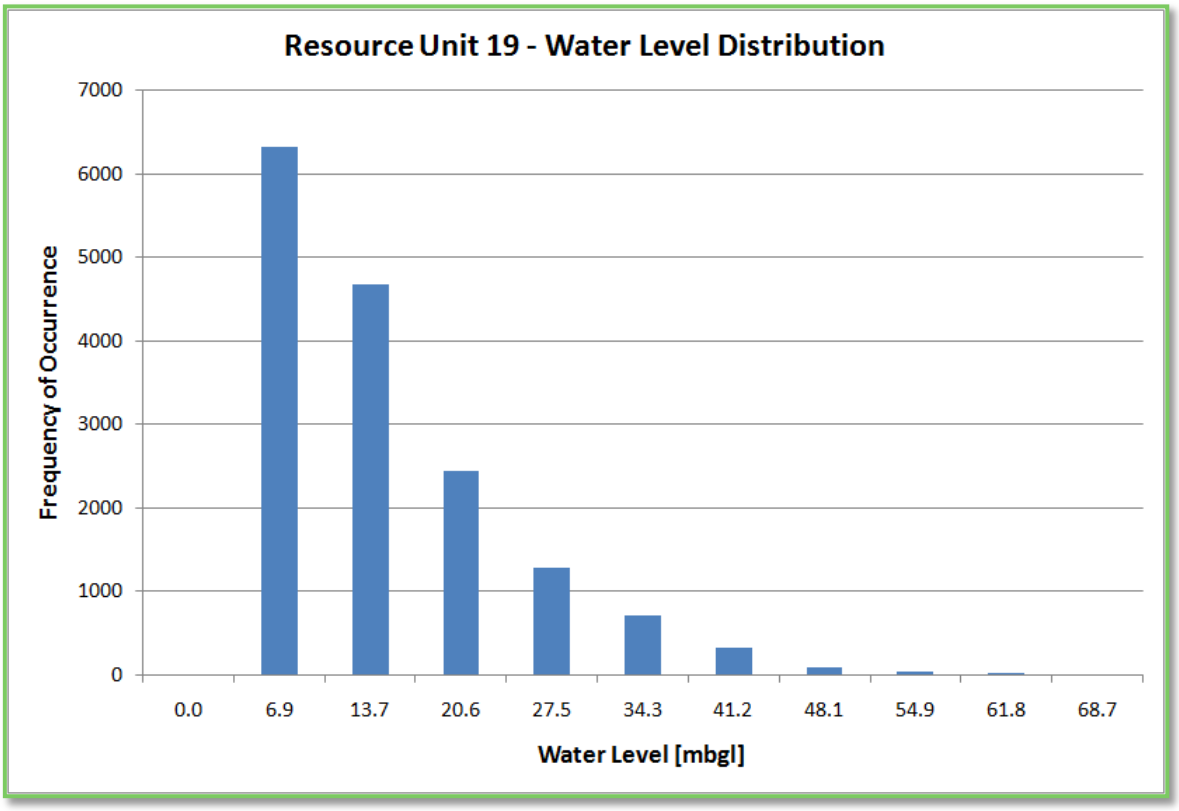

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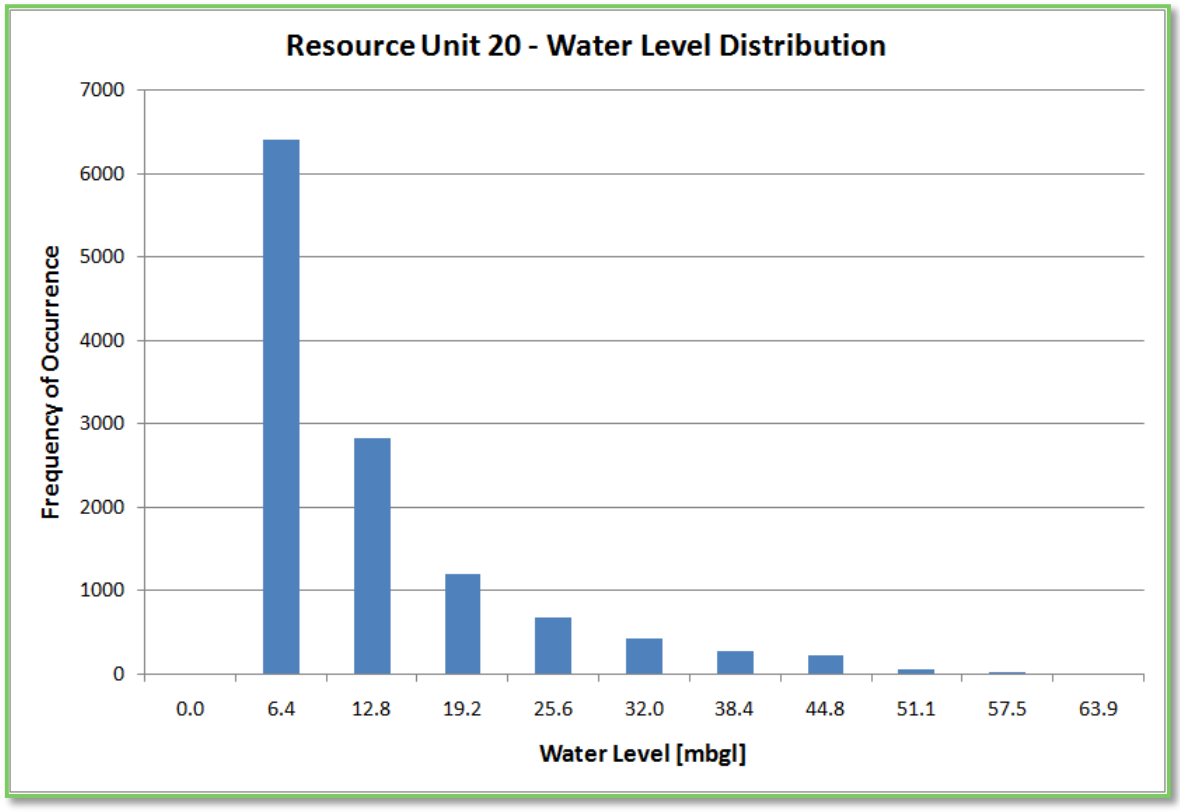
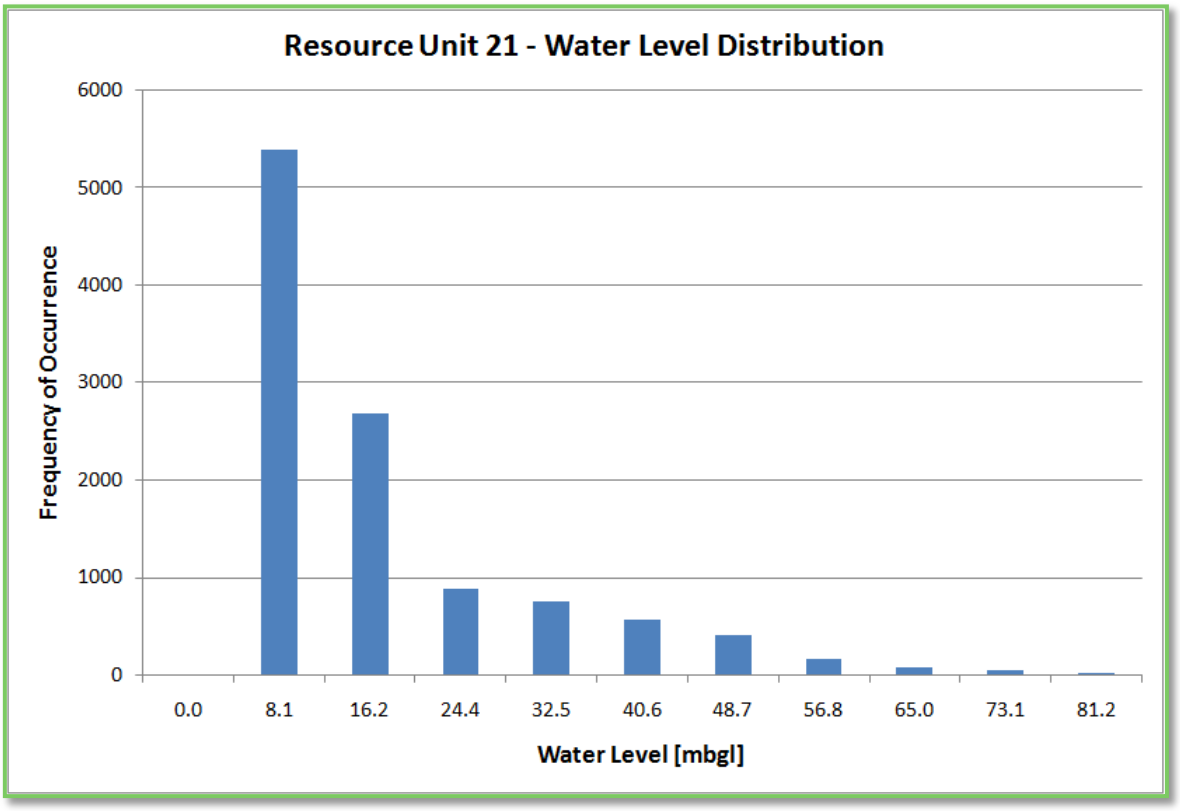


FIGURE B 20: WATER LEVEL HISTOGRAM FOR RU20



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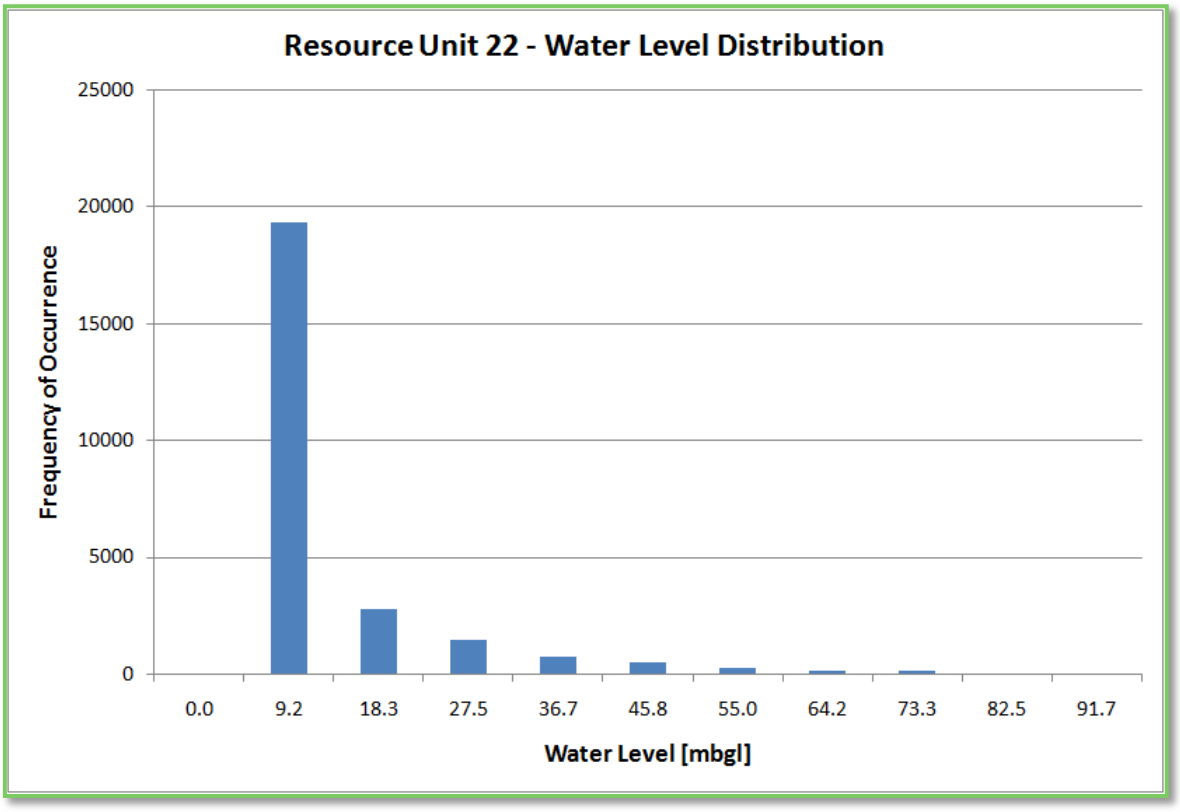

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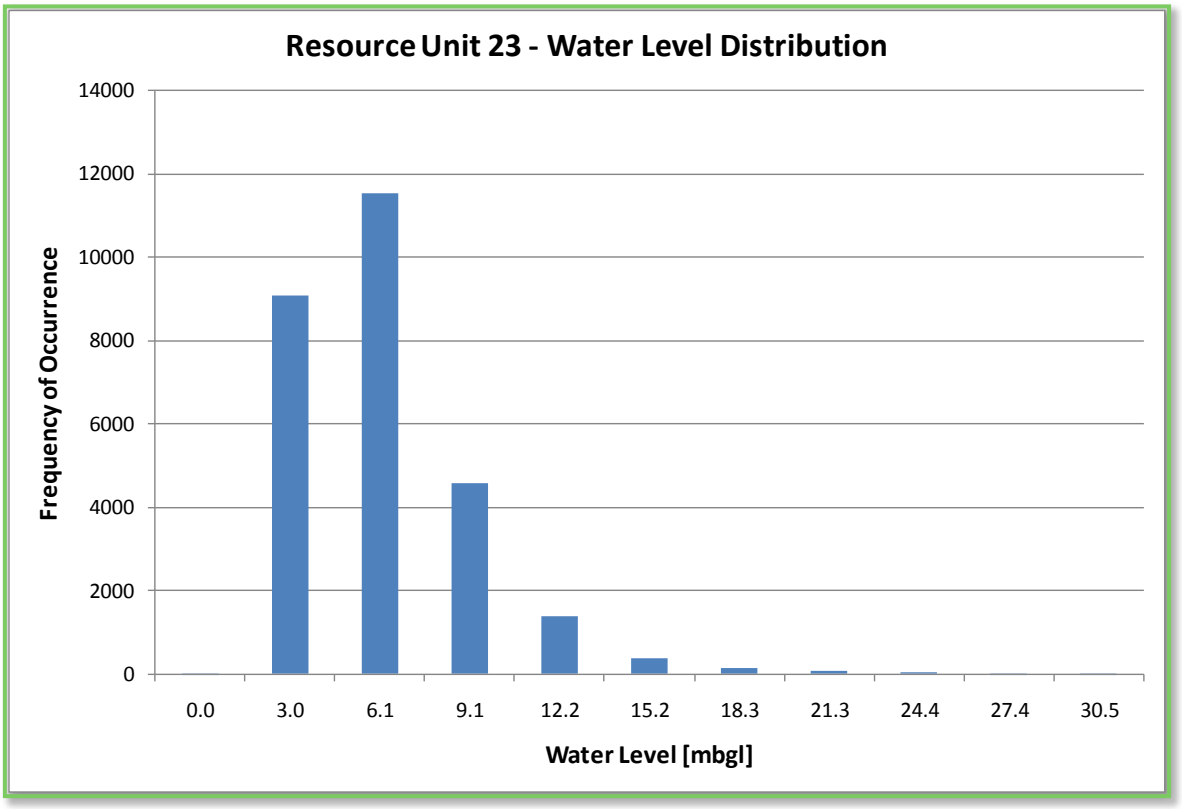

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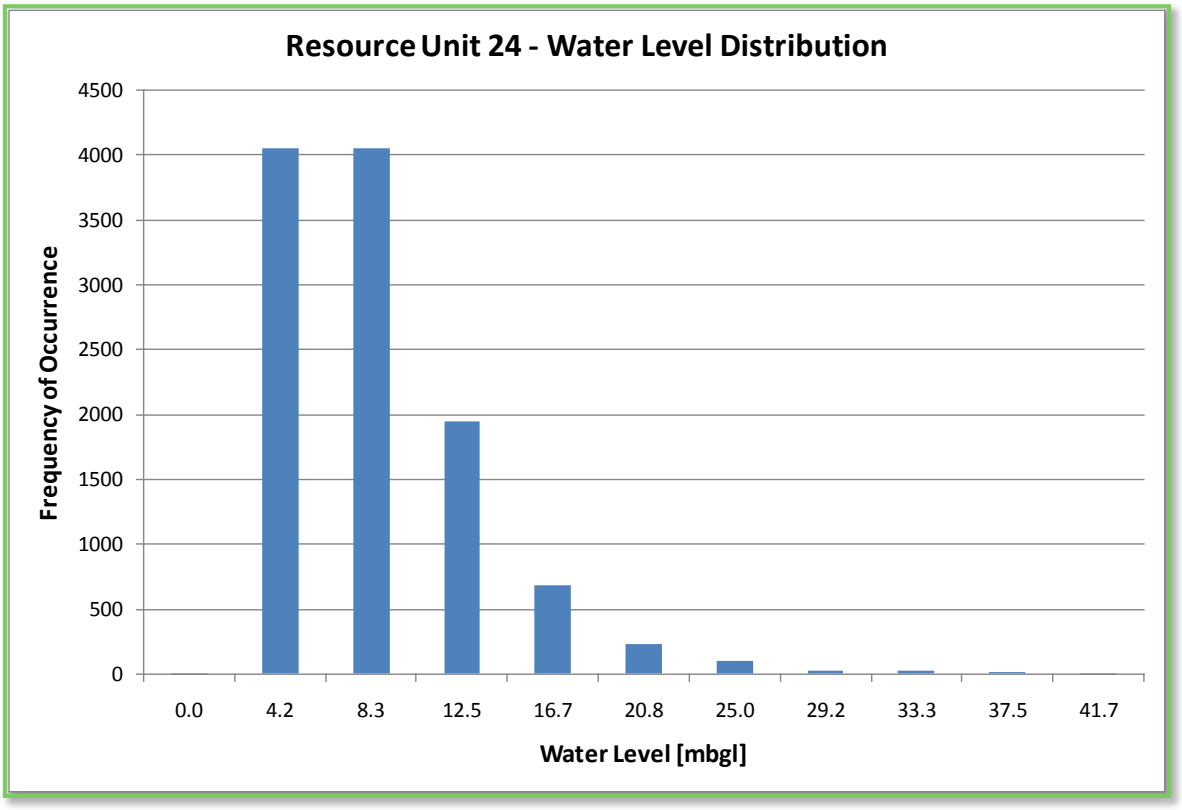

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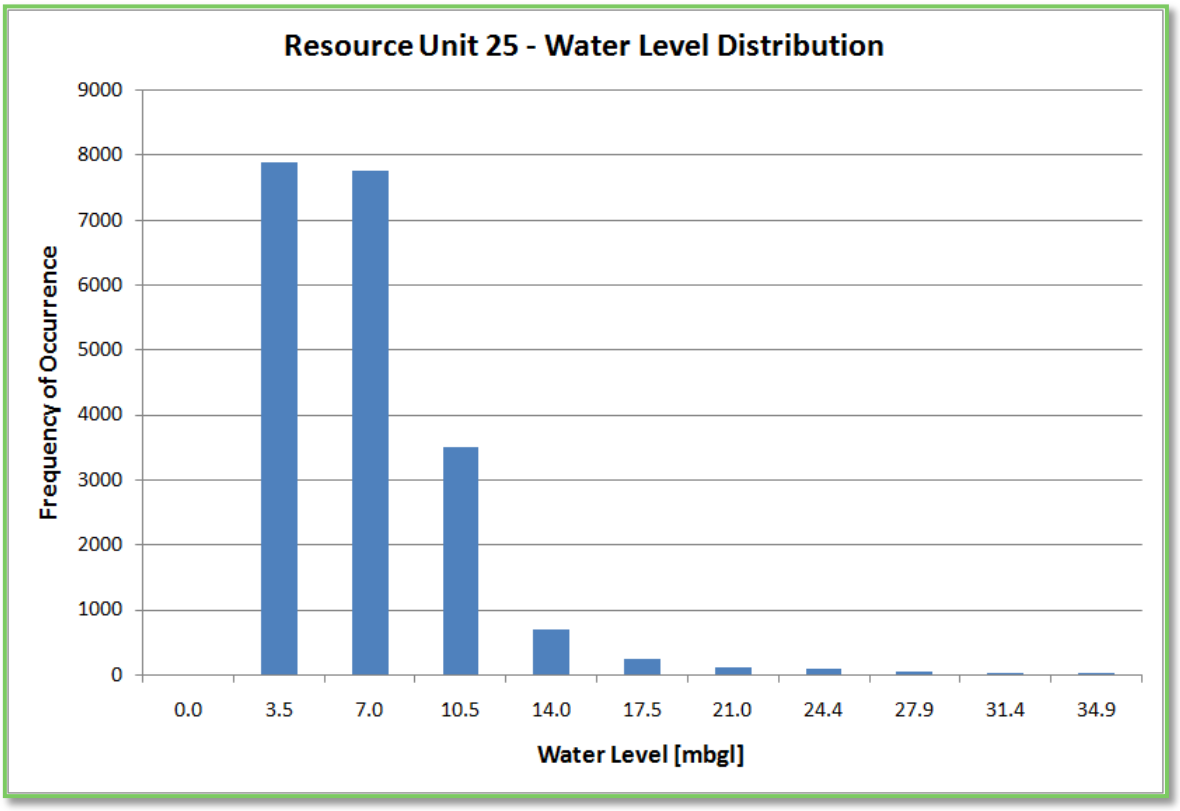

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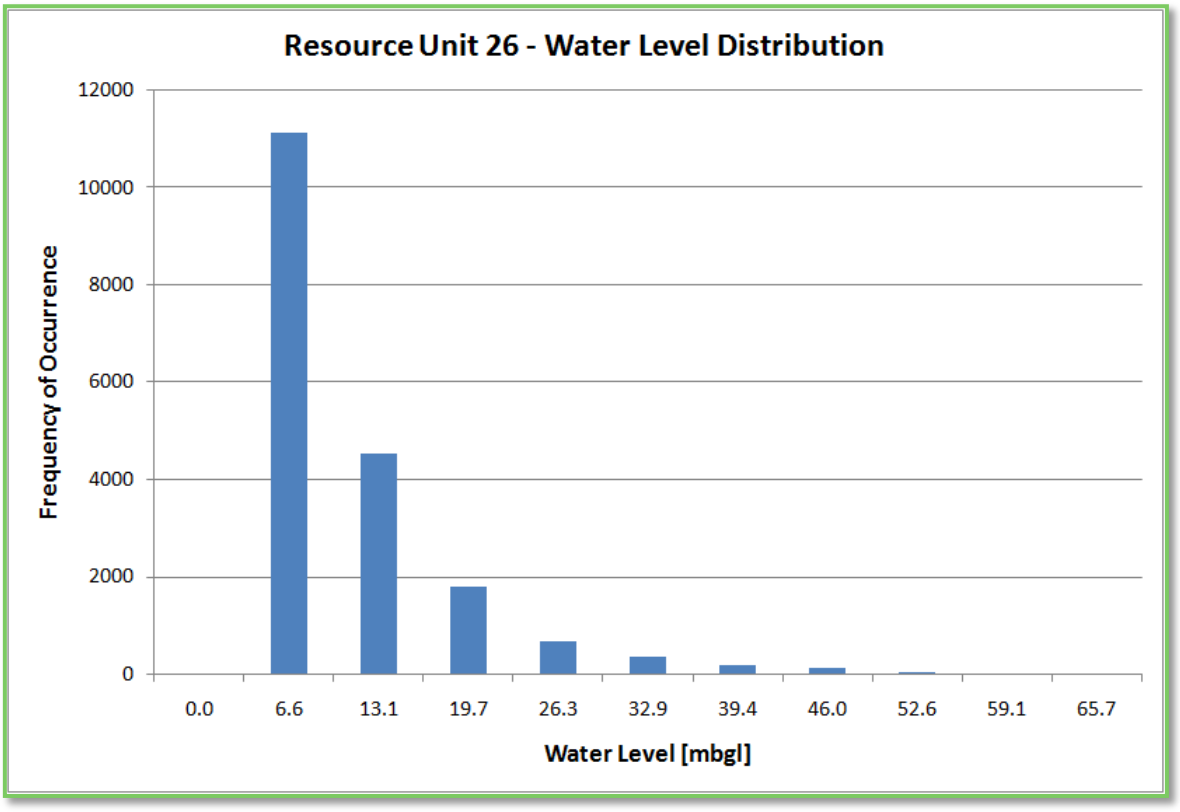


FIGURE B 26: WATER LEVEL HISTOGRAM FOR RU26

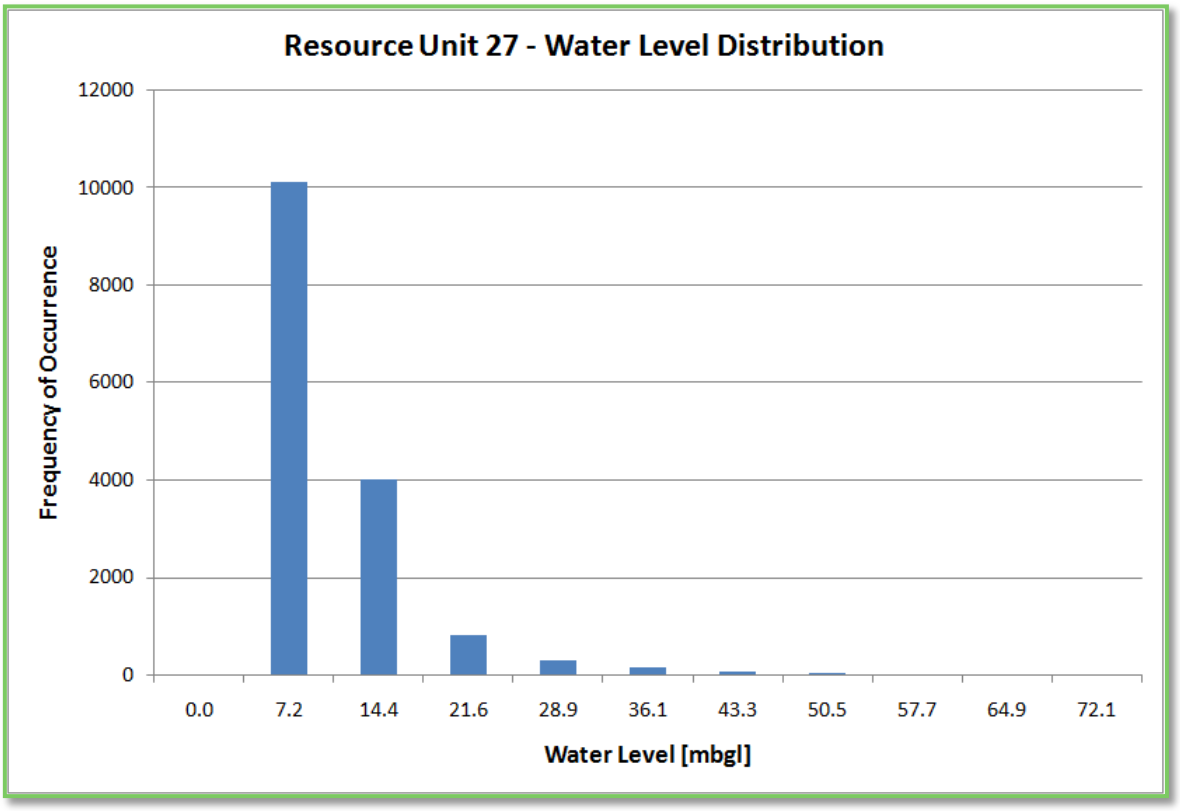


FIGURE B 27: WATER LEVEL HISTOGRAM FOR RU27

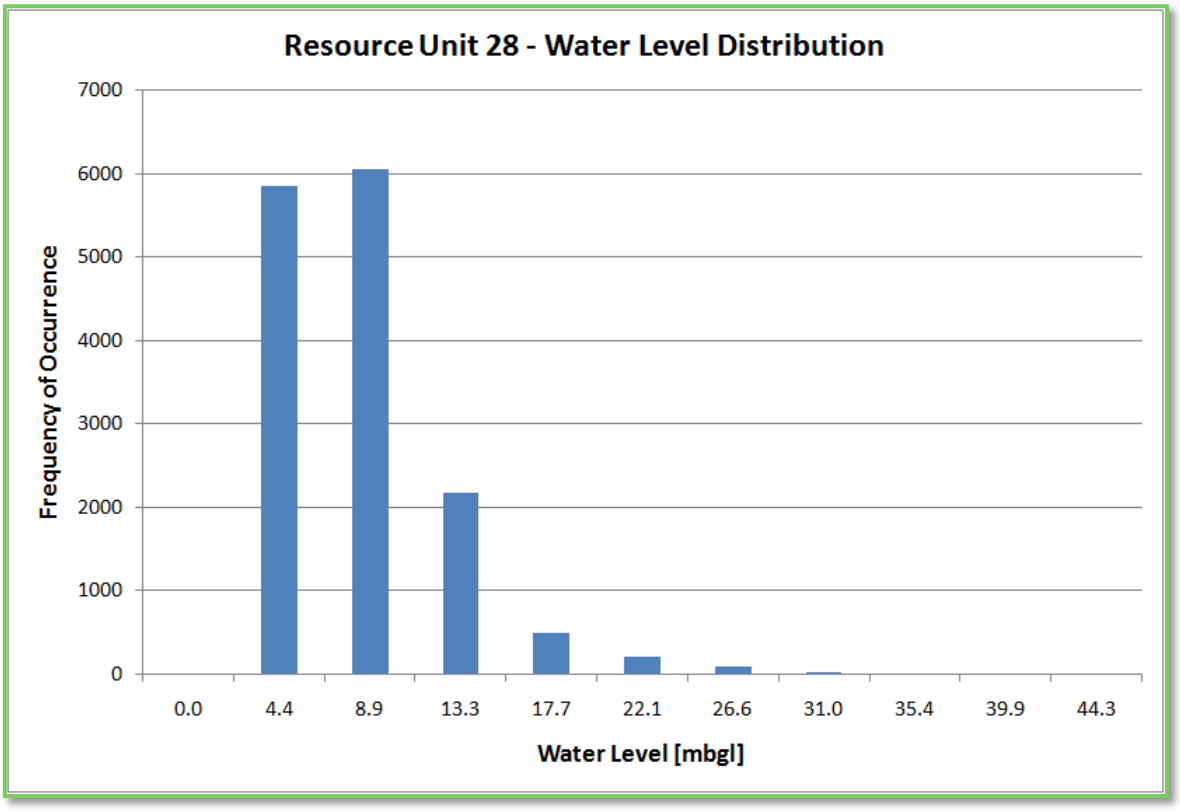


FIGURE B 28: WATER LEVEL HISTOGRAM FOR RU28

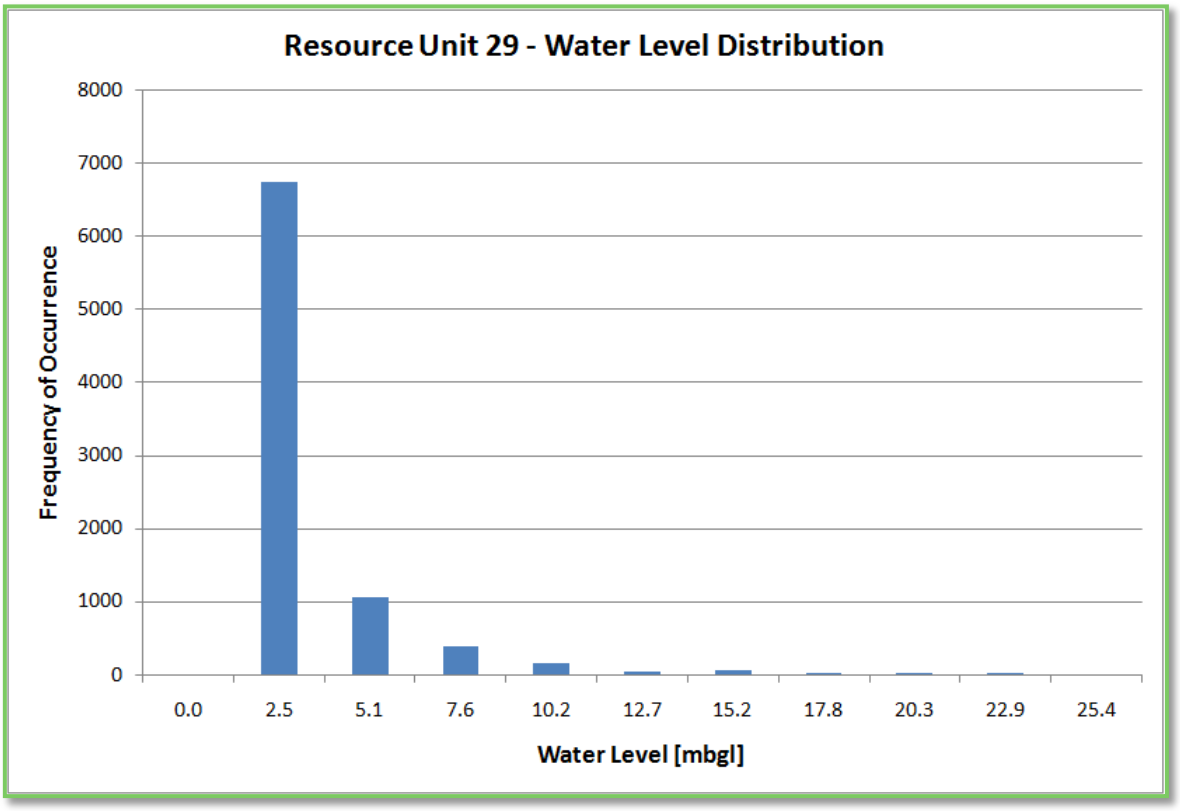


FIGURE B 29: WATER LEVEL HISTOGRAM FOR RU29

APPENDIX C: BASEFLOW

Resource Unit 1

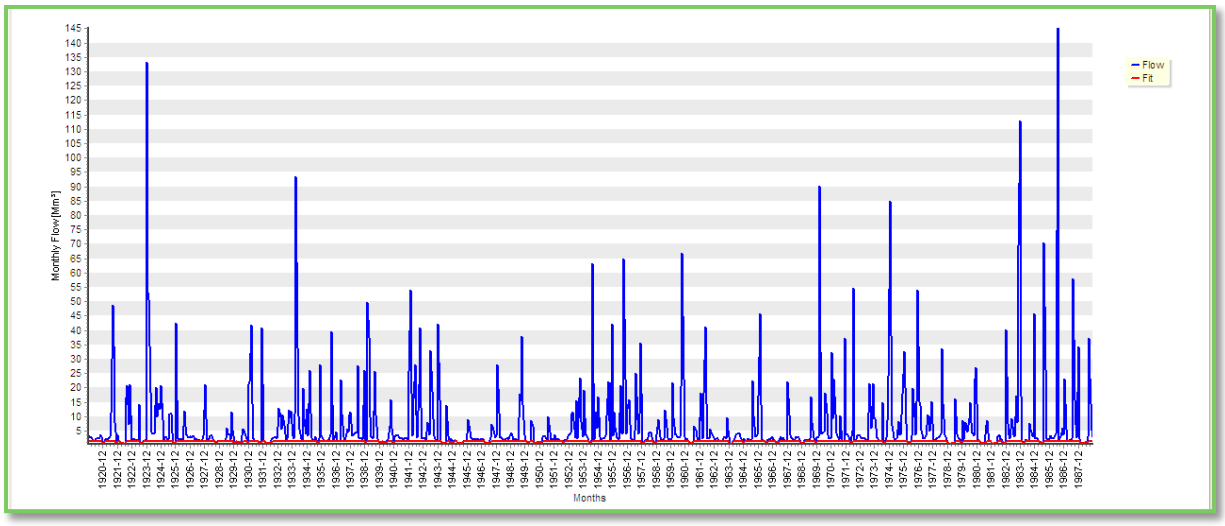


FIGURE C 1: BASEFLOW SEPARATION FOR CATCHMENT W11A

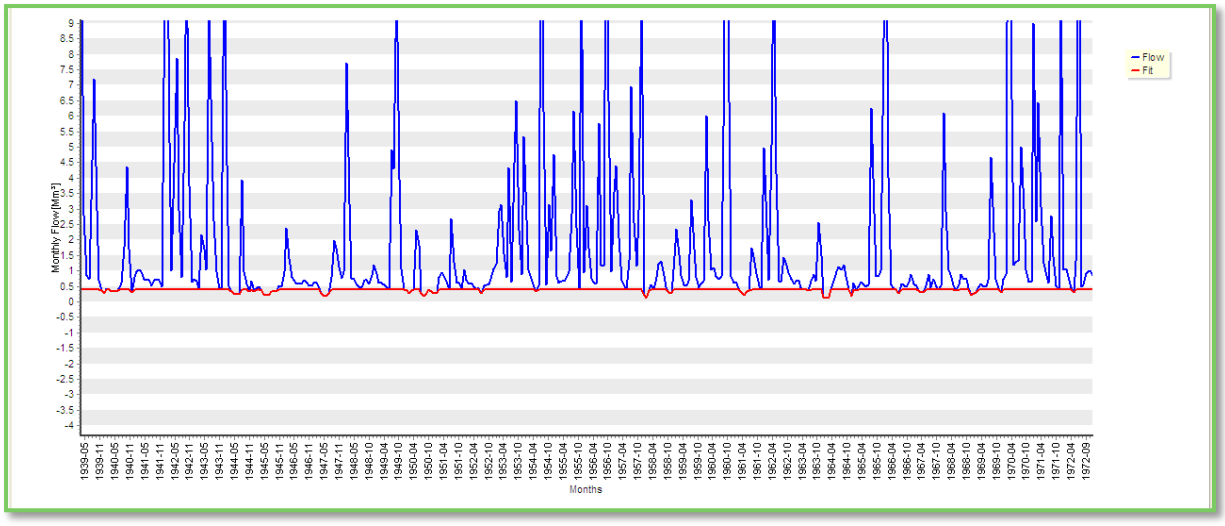


FIGURE C 2: BASEFLOW SEPARATION FOR CATCHMENT W11B

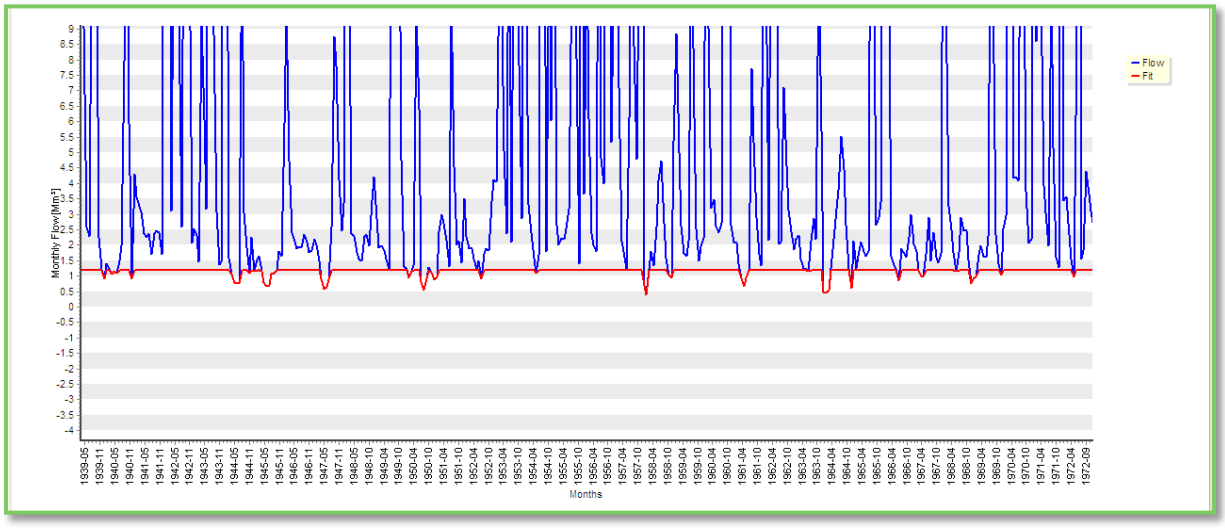


FIGURE C 3: BASEFLOW SEPARATION FOR CATCHMENT W11C

Resource Unit 2

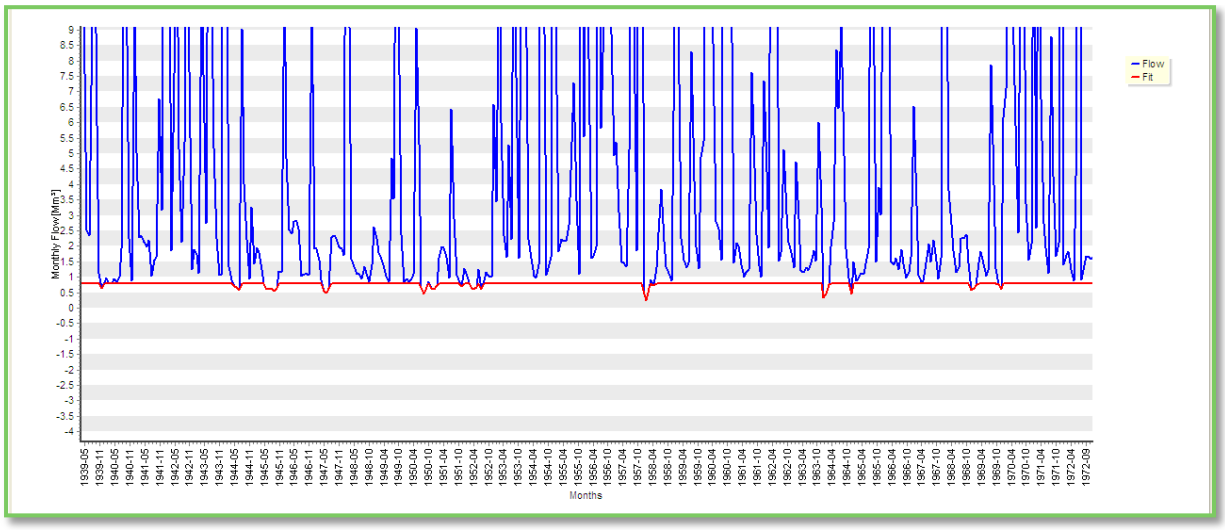


FIGURE C 4: BASEFLOW SEPARATION FOR CATCHMENT W13A

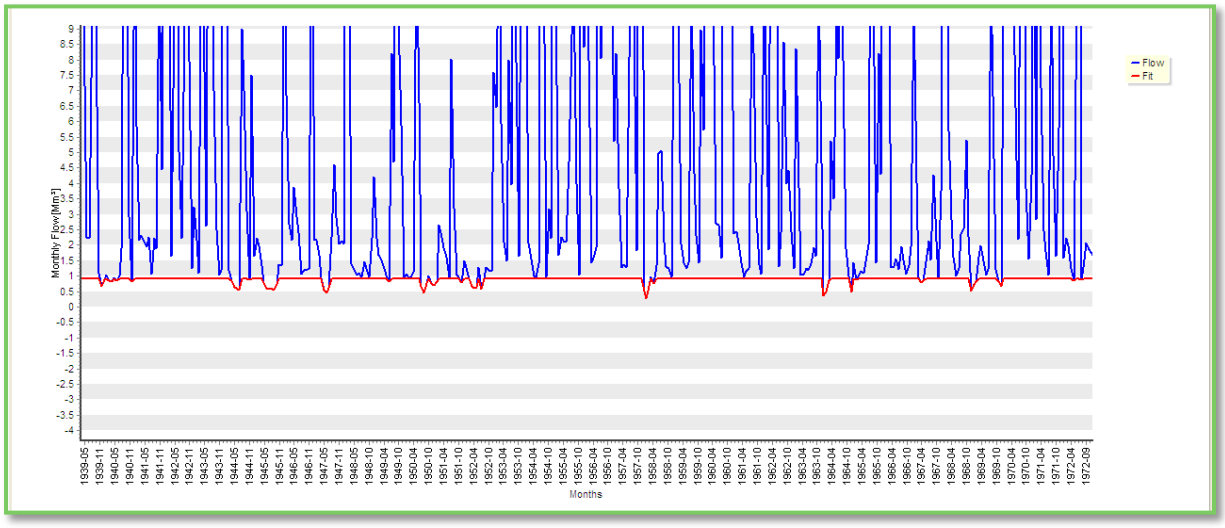


FIGURE C 5: BASEFLOW SEPARATION FOR CATCHMENT W13B

Resource Unit 3

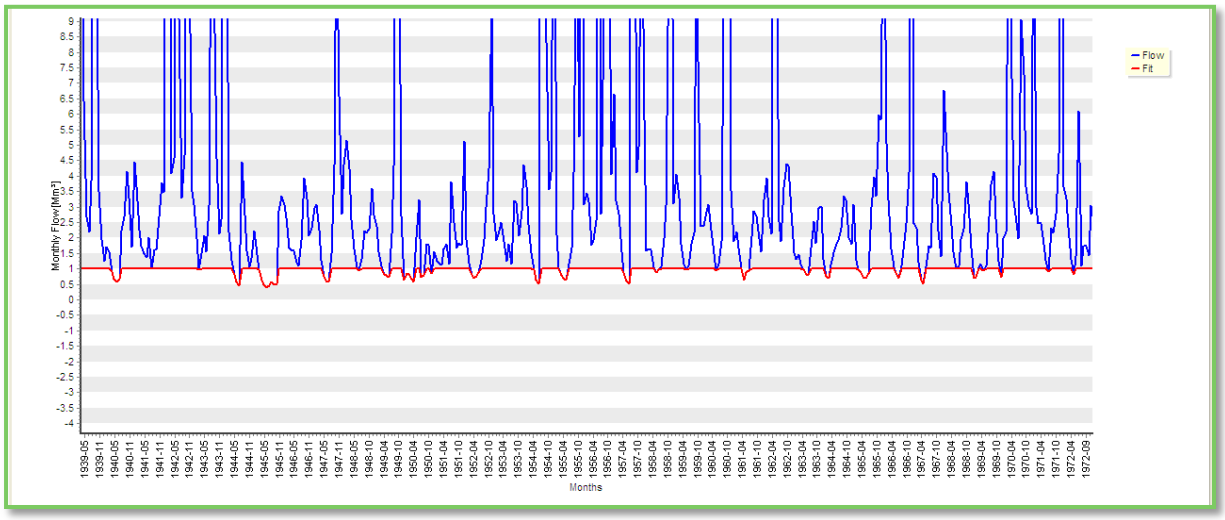


FIGURE C 6: BASEFLOW SEPARATION FOR CATCHMENT W12A

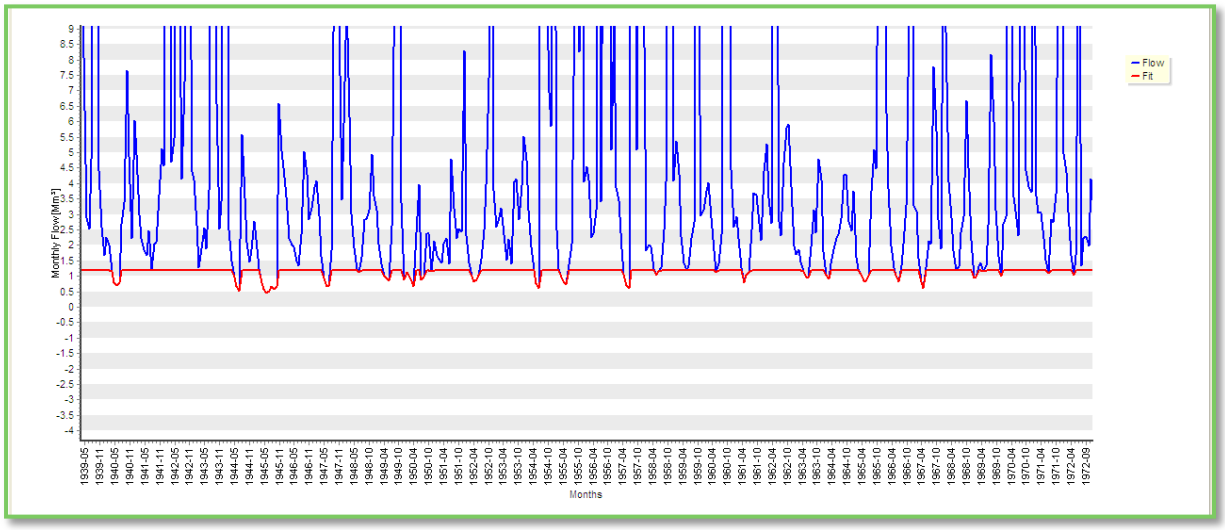


FIGURE C 7: BASEFLOW SEPARATION FOR CATCHMENT W12B

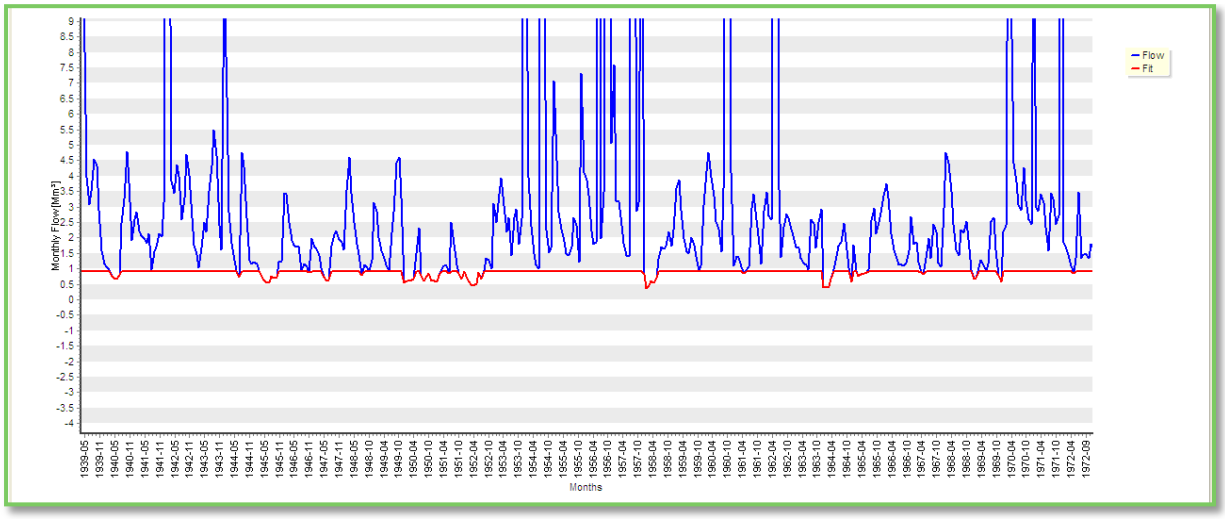


FIGURE C 8: BASEFLOW SEPARATION FOR CATCHMENT W12C

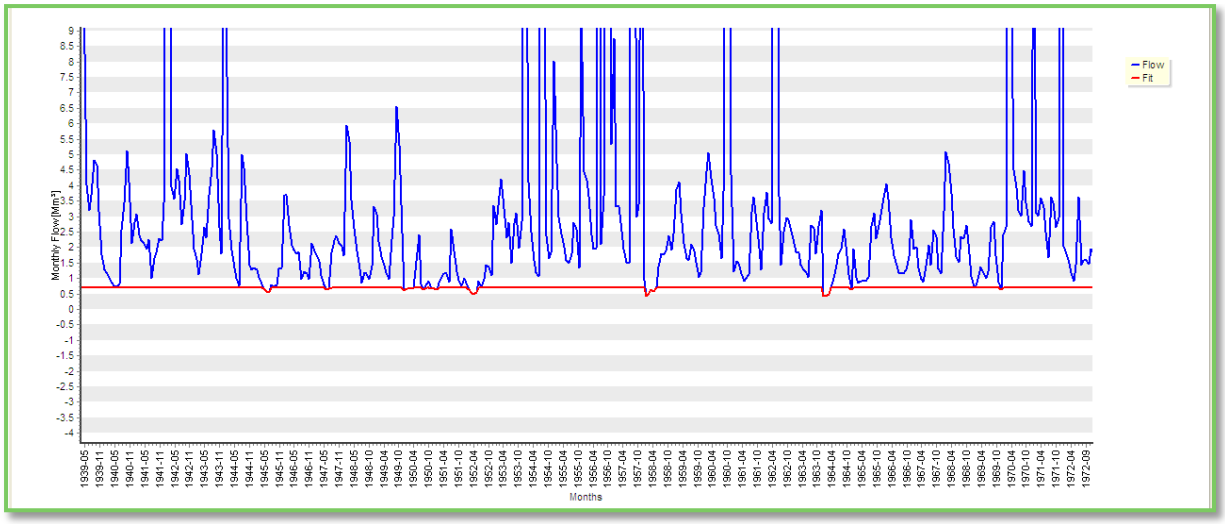


FIGURE C 9: BASEFLOW SEPARATION FOR CATCHMENT W12D

Resource Unit 4

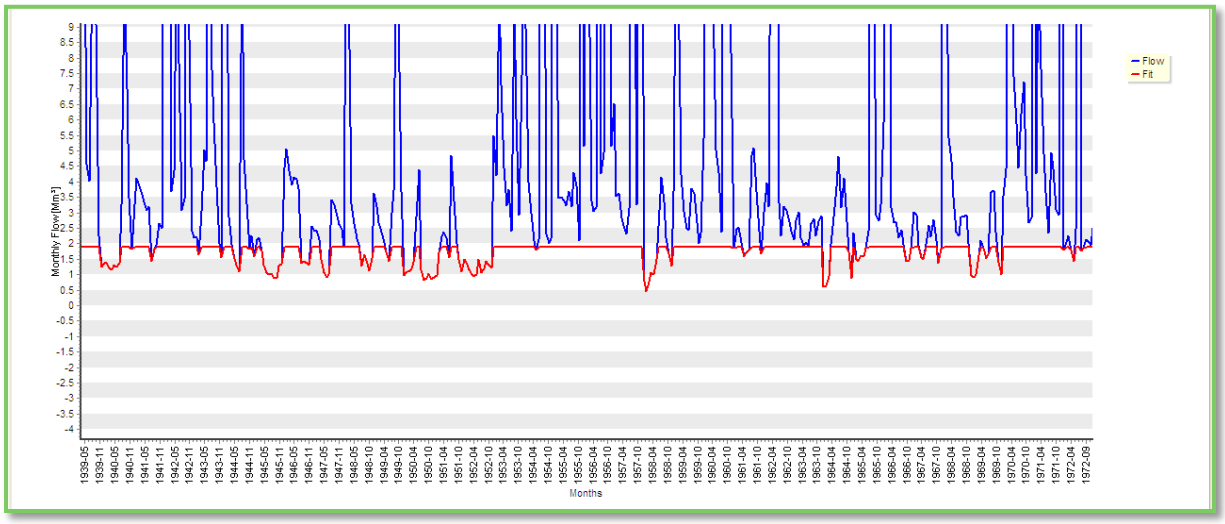


FIGURE C 10: BASEFLOW SEPARATION FOR CATCHMENT W12F

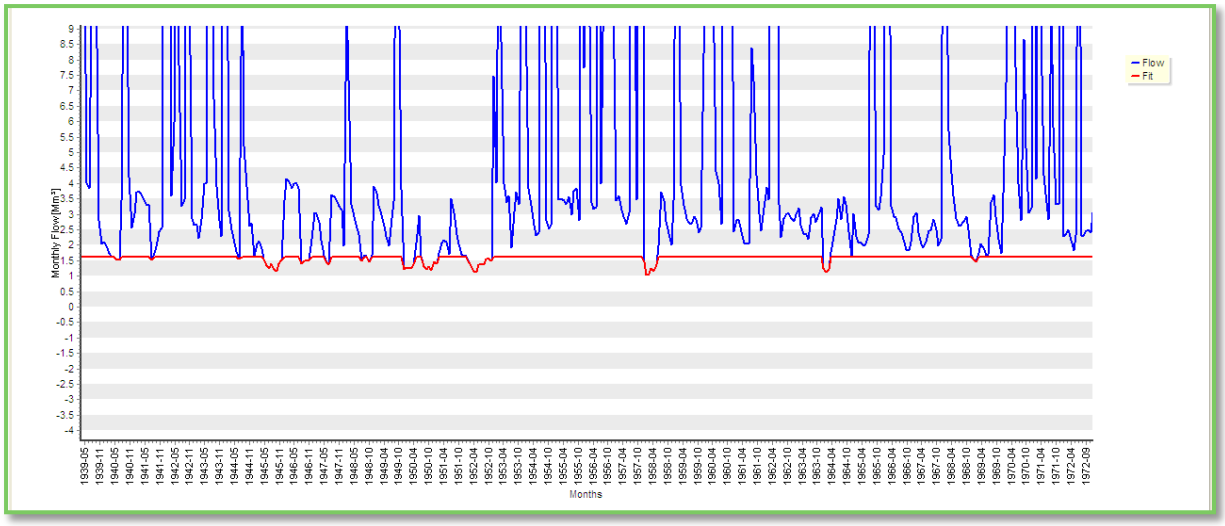


FIGURE C 11: BASEFLOW SEPARATION FOR CATCHMENT W12J

Resource Unit 5

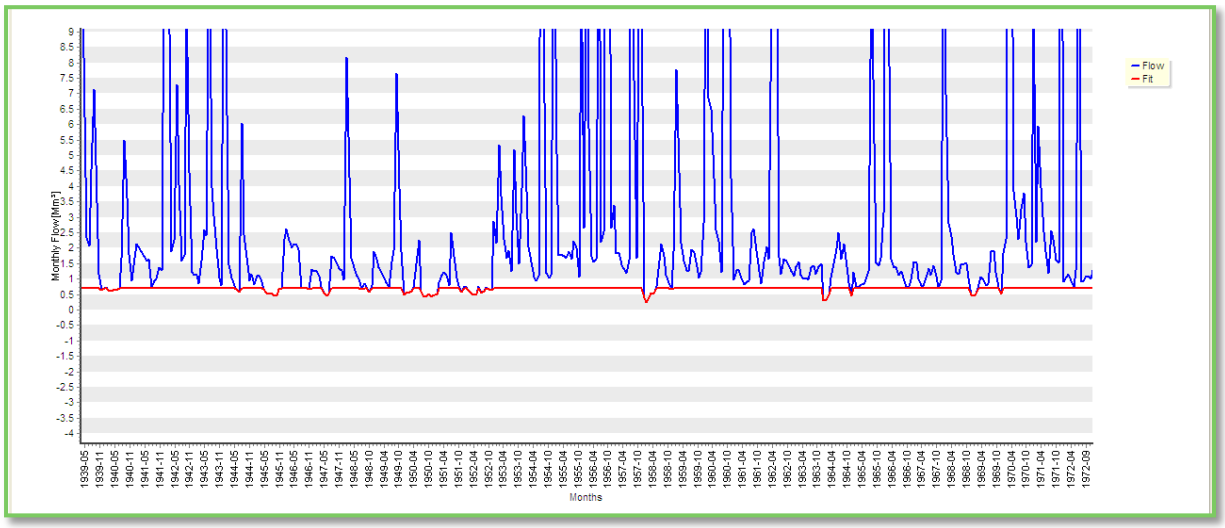


FIGURE C 12: BASEFLOW SEPARATION FOR CATCHMENT W12E

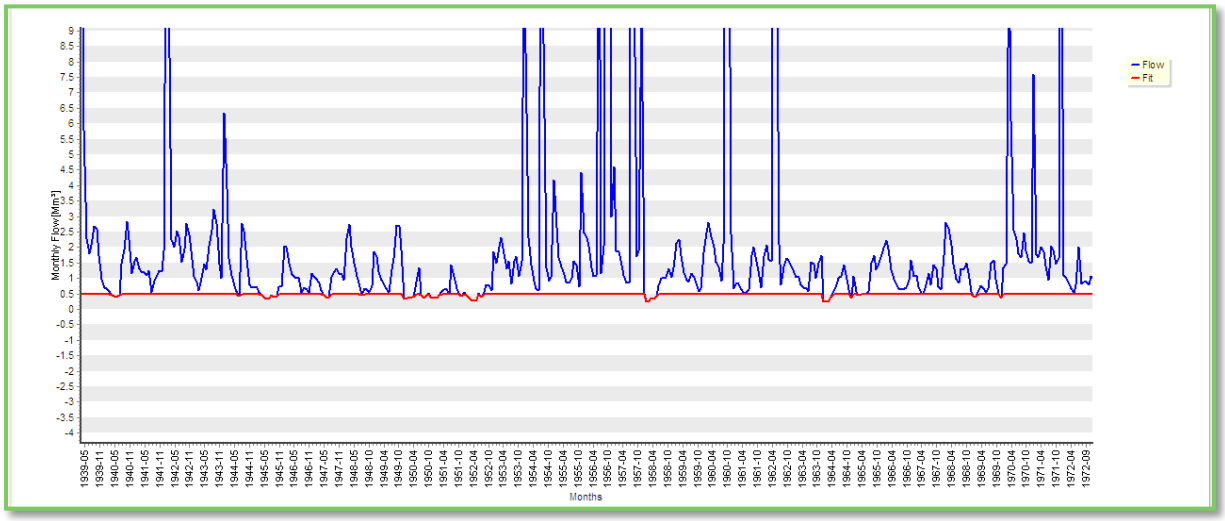


FIGURE C 13: BASEFLOW SEPARATION FOR CATCHMENT W12G

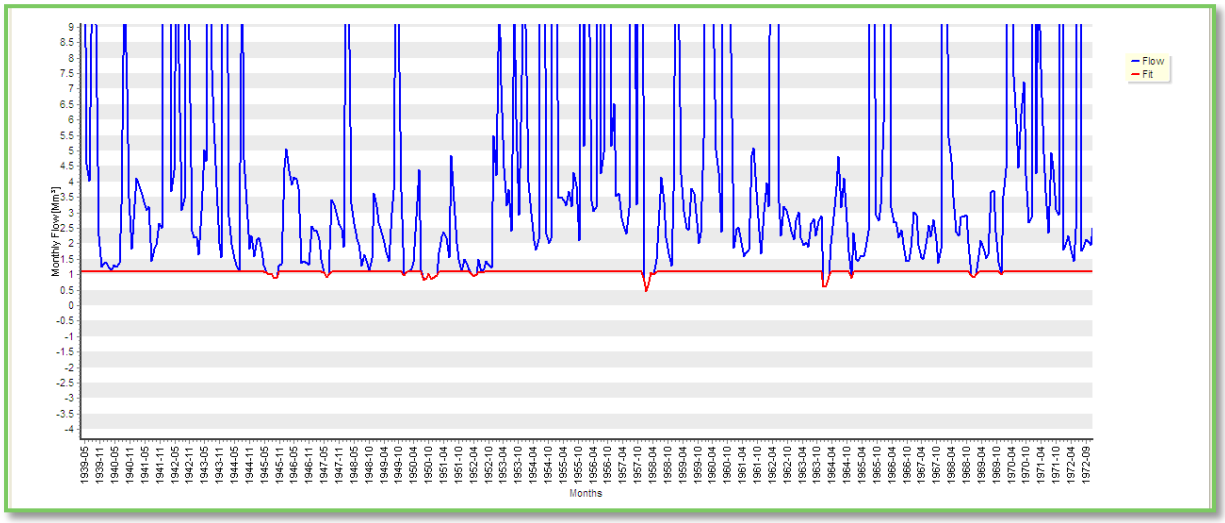


FIGURE C 14: BASEFLOW SEPARATION FOR CATCHMENT W12H

Resource Unit 6

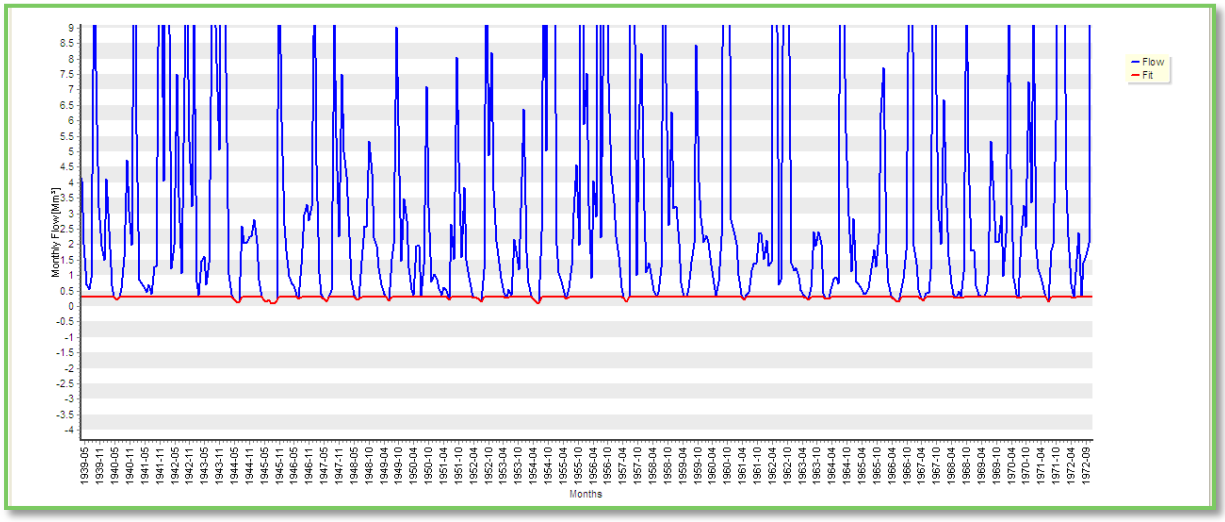


FIGURE C 15: BASEFLOW SEPARATION FOR CATCHMENT W21A

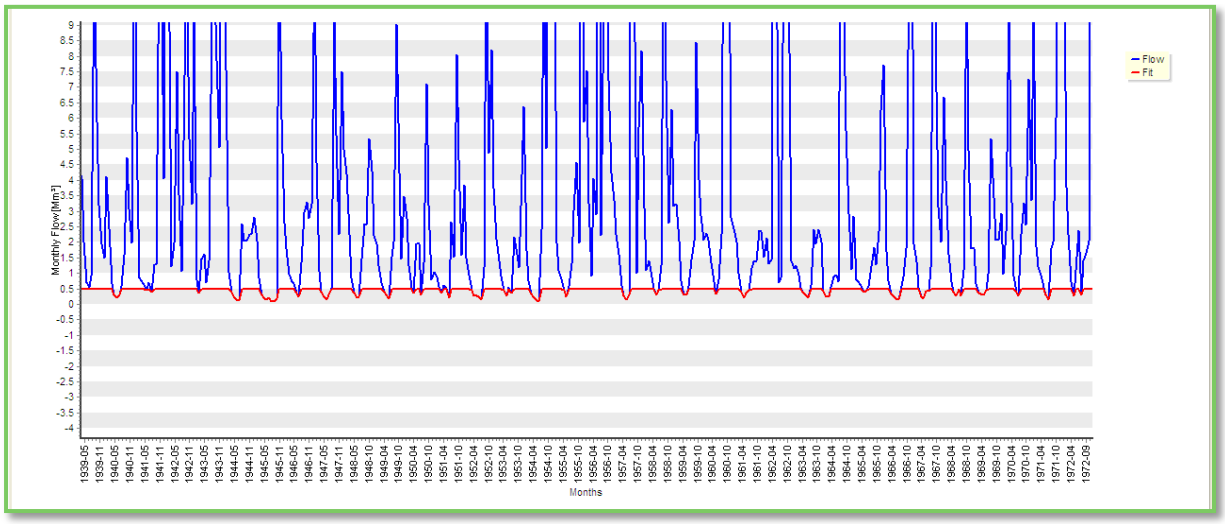


FIGURE C 16: BASEFLOW SEPARATION FOR CATCHMENT W21B

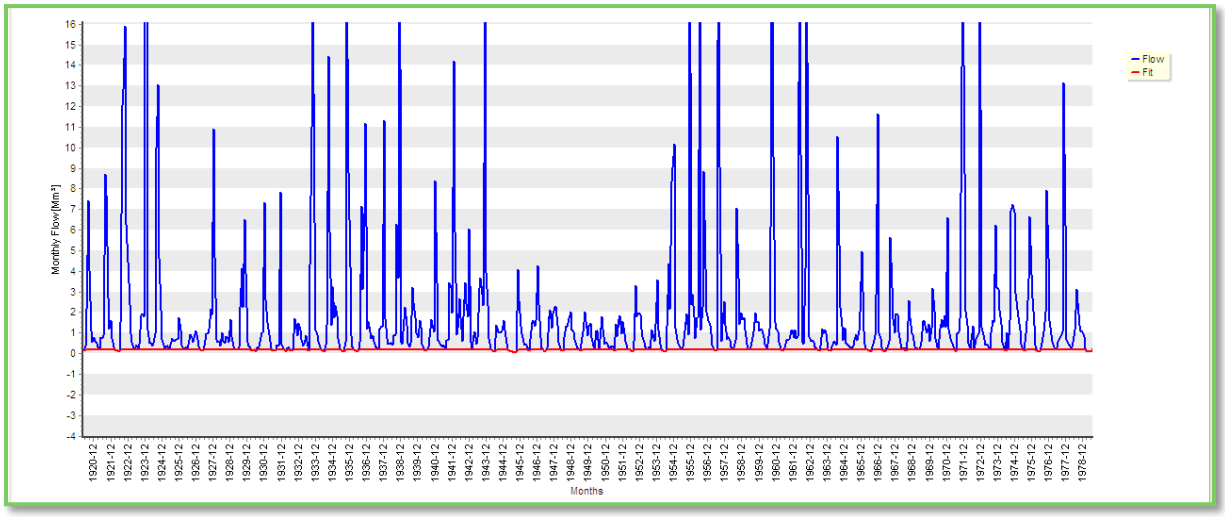


FIGURE C 17: BASEFLOW SEPARATION FOR CATCHMENT W21C

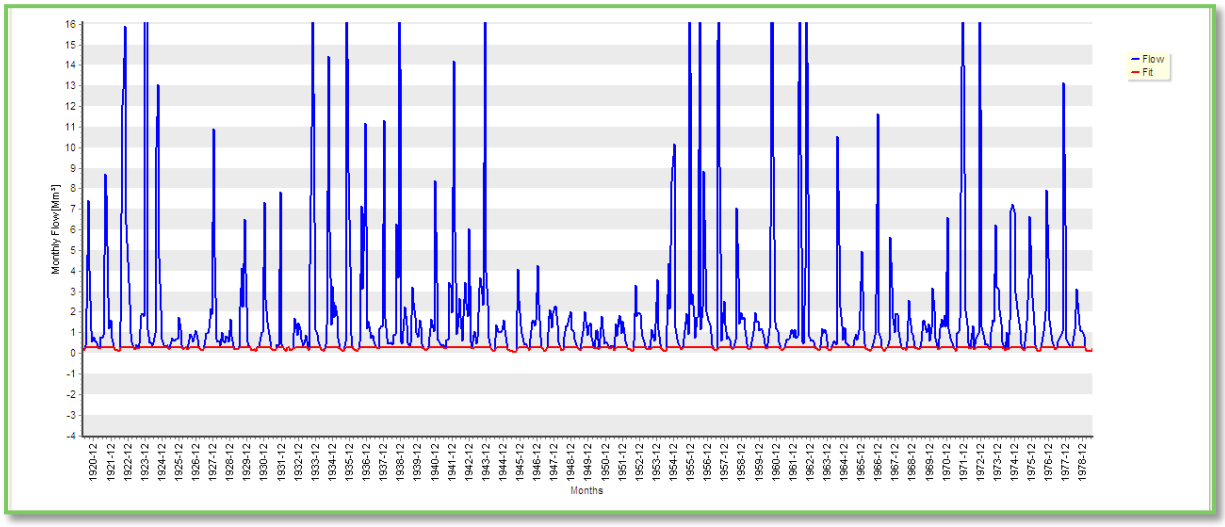


FIGURE C 18: BASEFLOW SEPARATION FOR CATCHMENT W21D

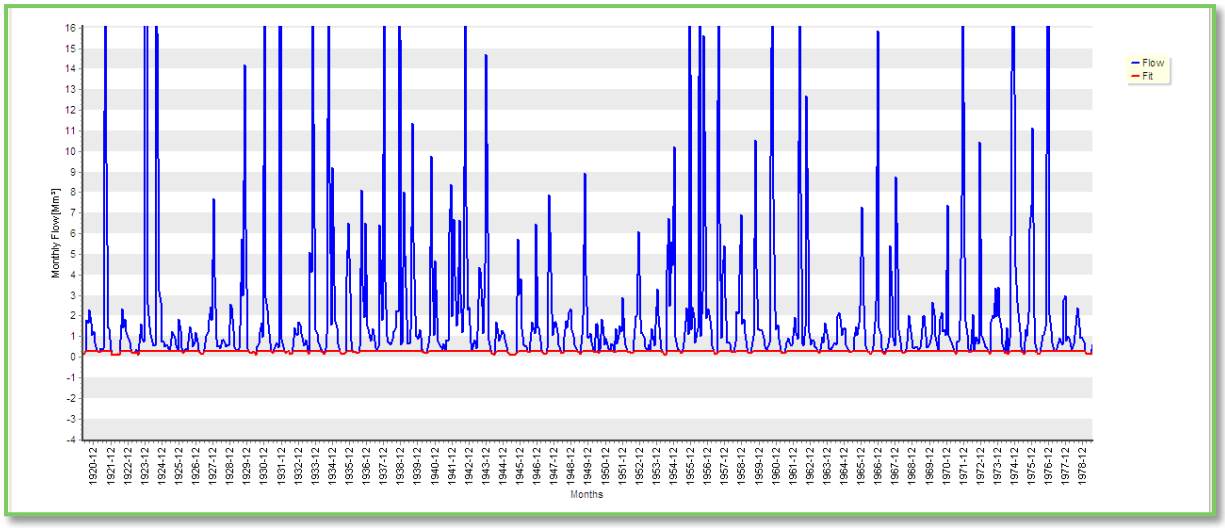


FIGURE C 19: BASEFLOW SEPARATION FOR CATCHMENT W21E

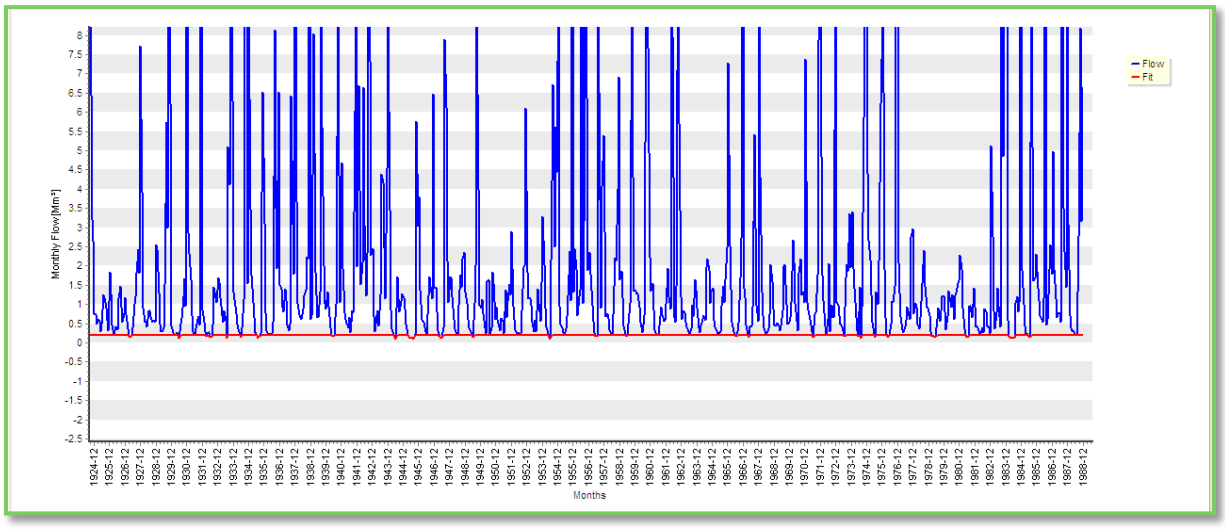


FIGURE C 20: BASEFLOW SEPARATION FOR CATCHMENT W21F

Resource Unit 7

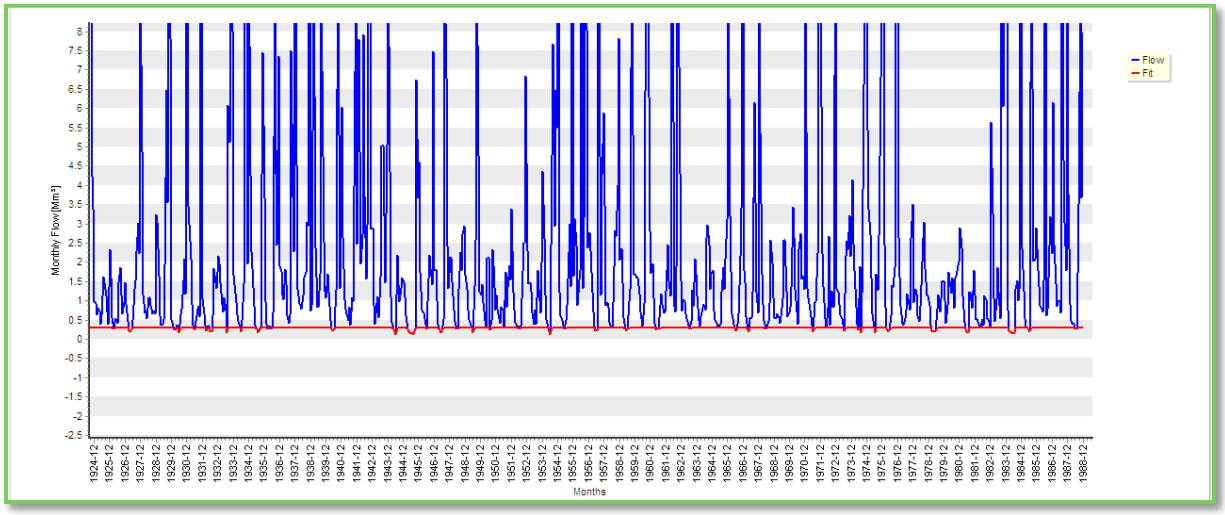


FIGURE C 21: BASEFLOW SEPARATION FOR CATCHMENT W21G

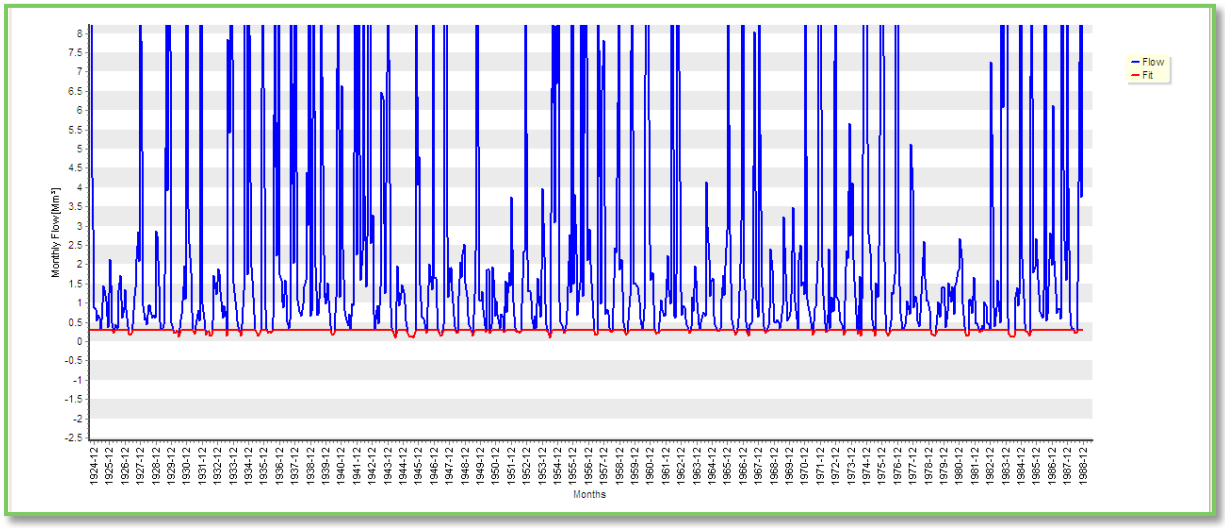


FIGURE C 22: BASEFLOW SEPARATION FOR CATCHMENT W21H

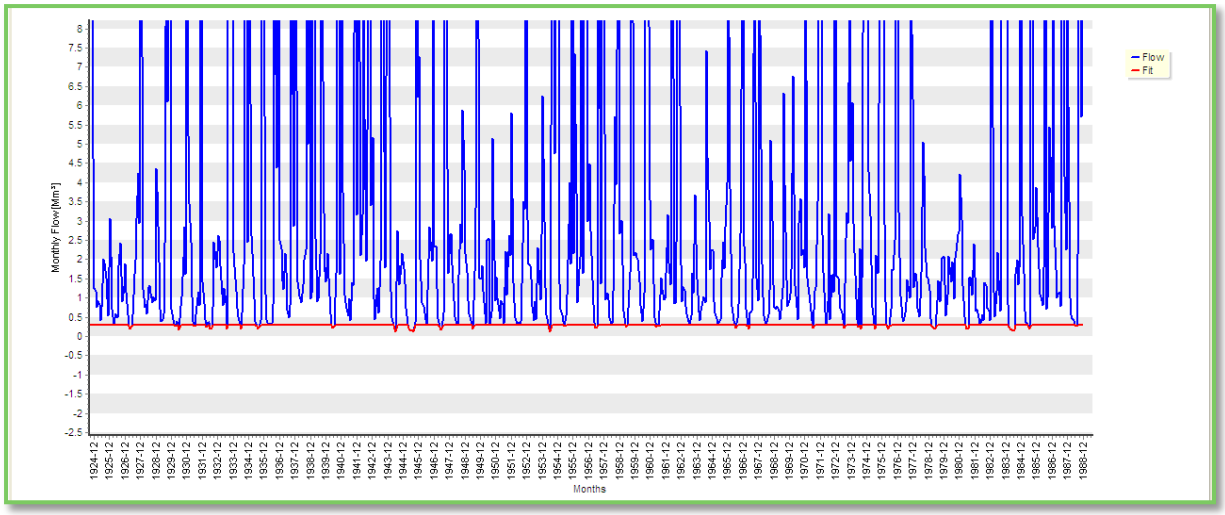


FIGURE C 23: BASEFLOW SEPARATION FOR CATCHMENT W21J

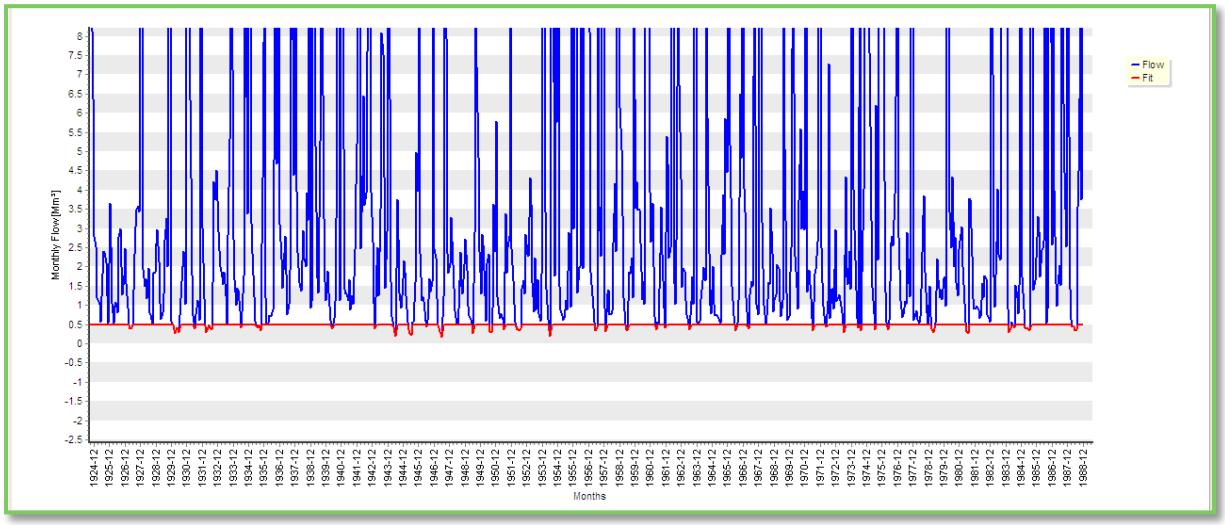


FIGURE C 24: BASEFLOW SEPARATION FOR CATCHMENT W21K

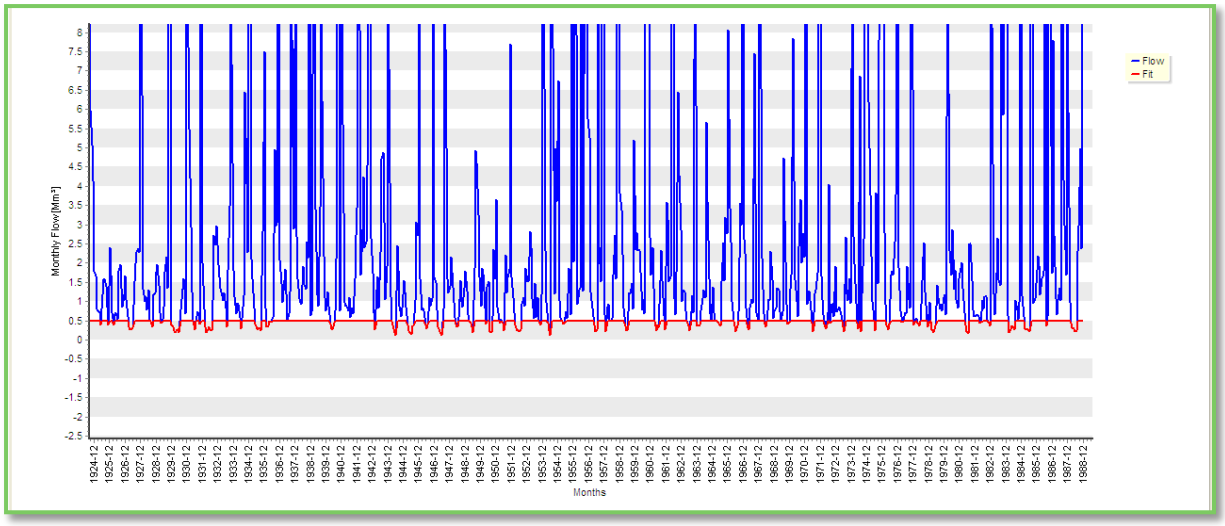


FIGURE C 25: BASEFLOW SEPARATION FOR CATCHMENT W21L

Resource Unit 8

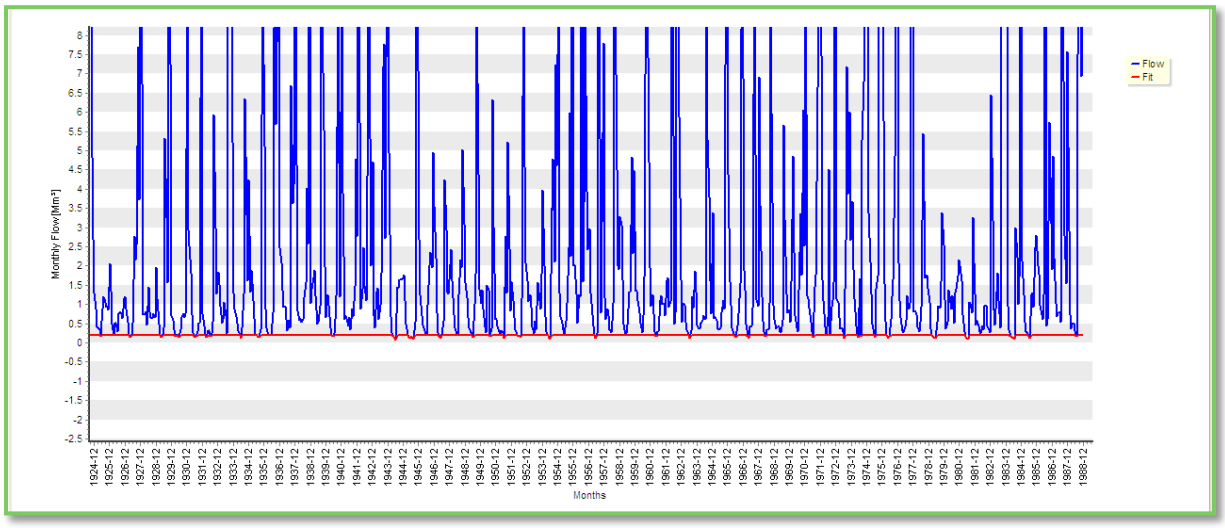


FIGURE C 26: BASEFLOW SEPARATION FOR CATCHMENT W22A

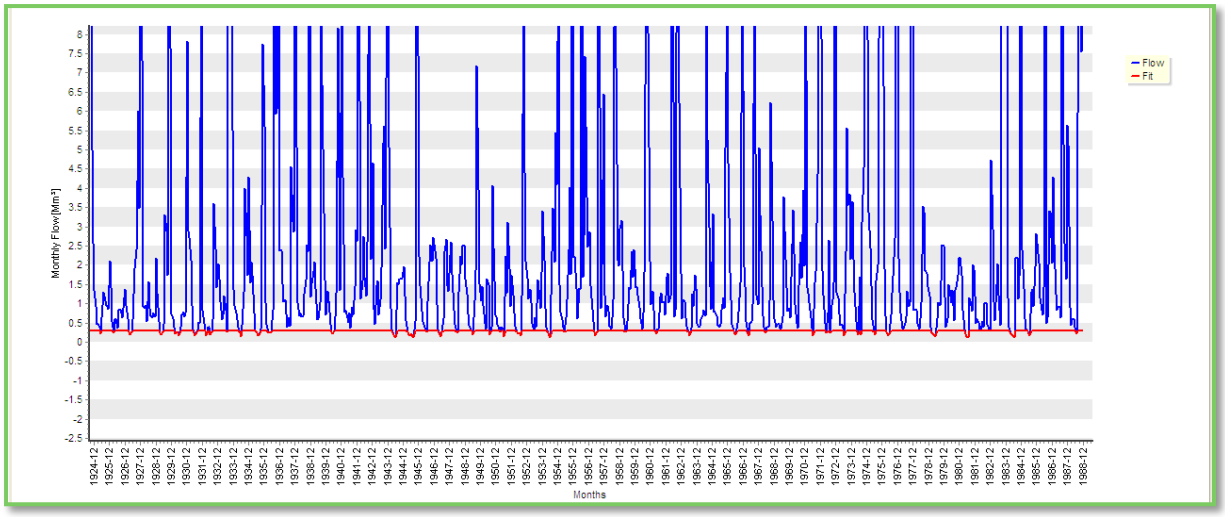


FIGURE C 27: BASEFLOW SEPARATION FOR CATCHMENT W22B

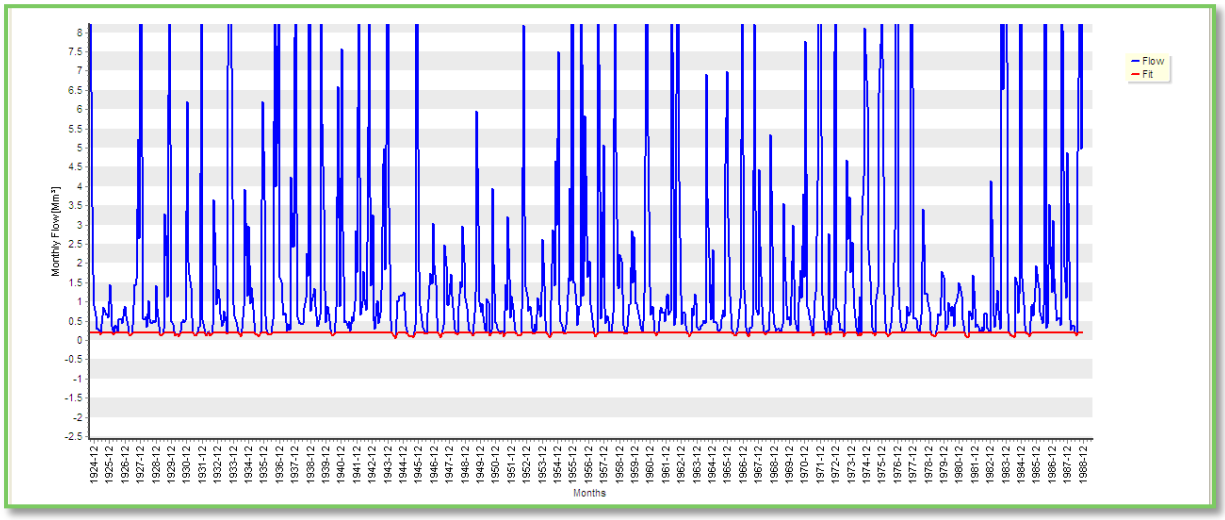


FIGURE C 28: BASEFLOW SEPARATION FOR CATCHMENT W22C

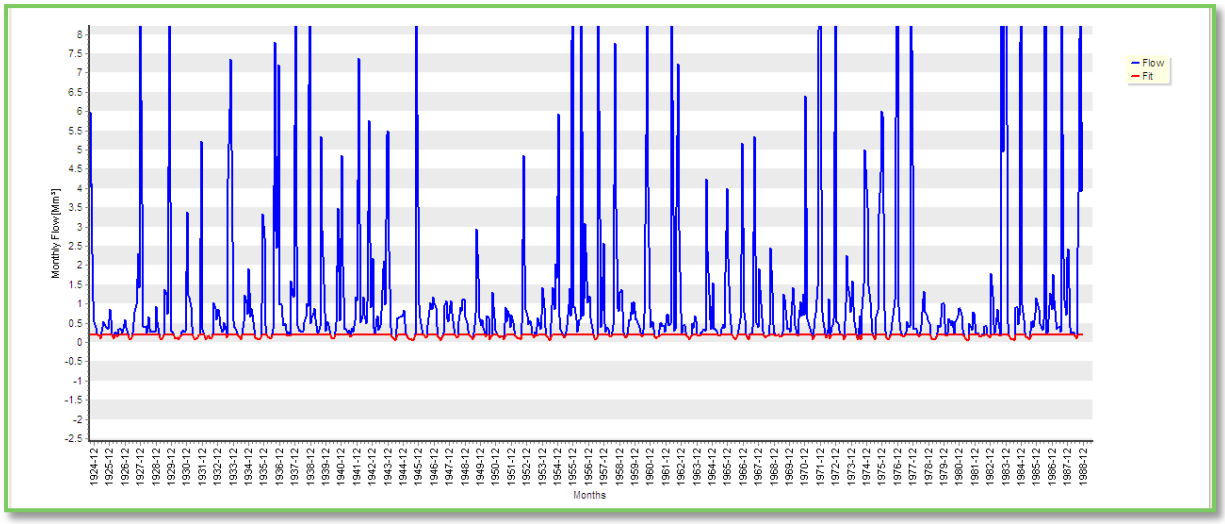


FIGURE C 29: BASEFLOW SEPARATION FOR CATCHMENT W22D

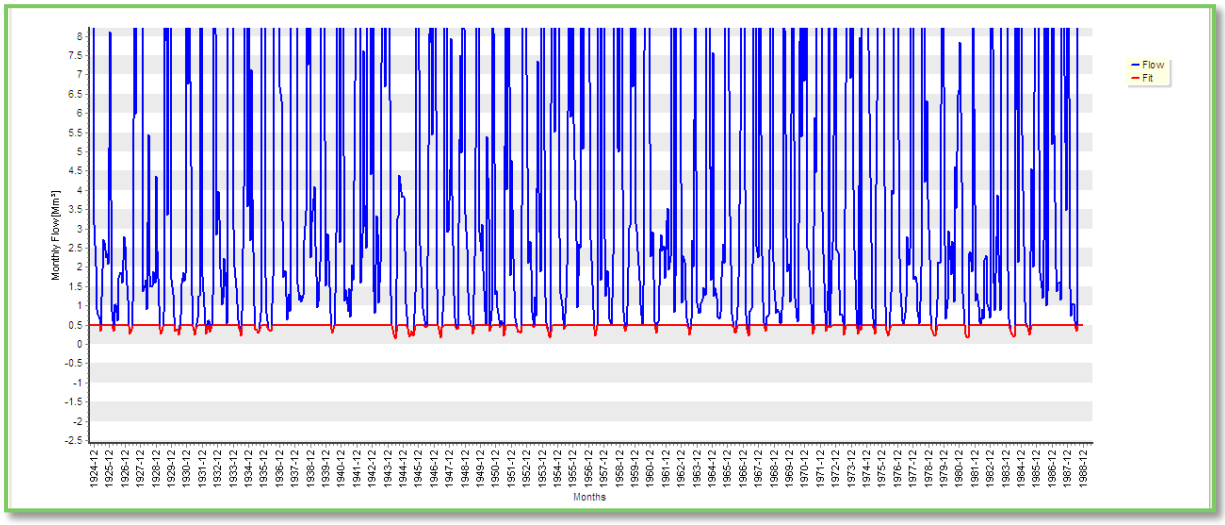


FIGURE C 30: BASEFLOW SEPARATION FOR CATCHMENT W22E

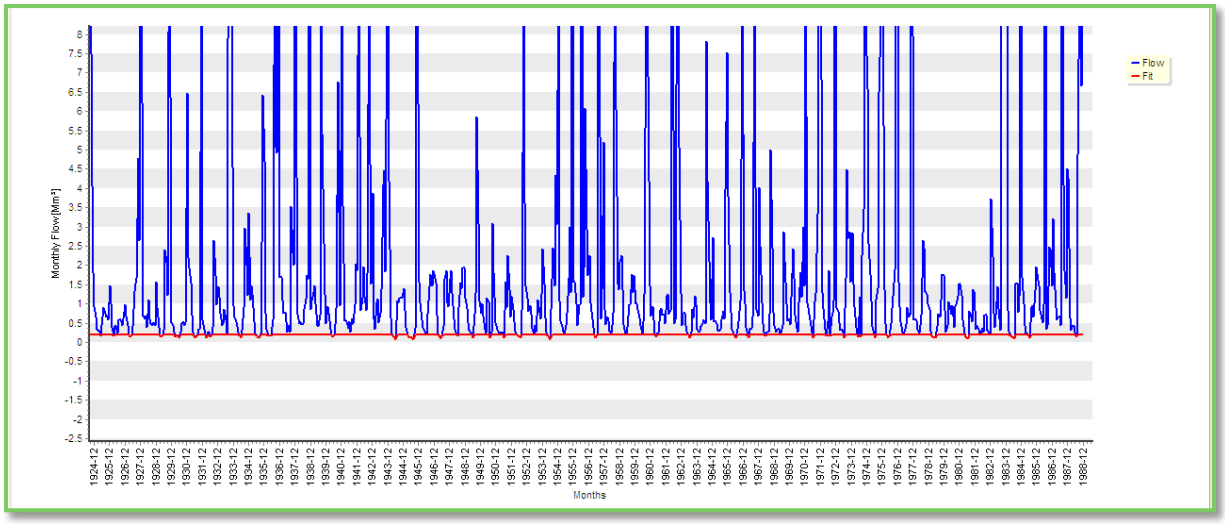


FIGURE C 31: BASEFLOW SEPARATION FOR CATCHMENT W22F

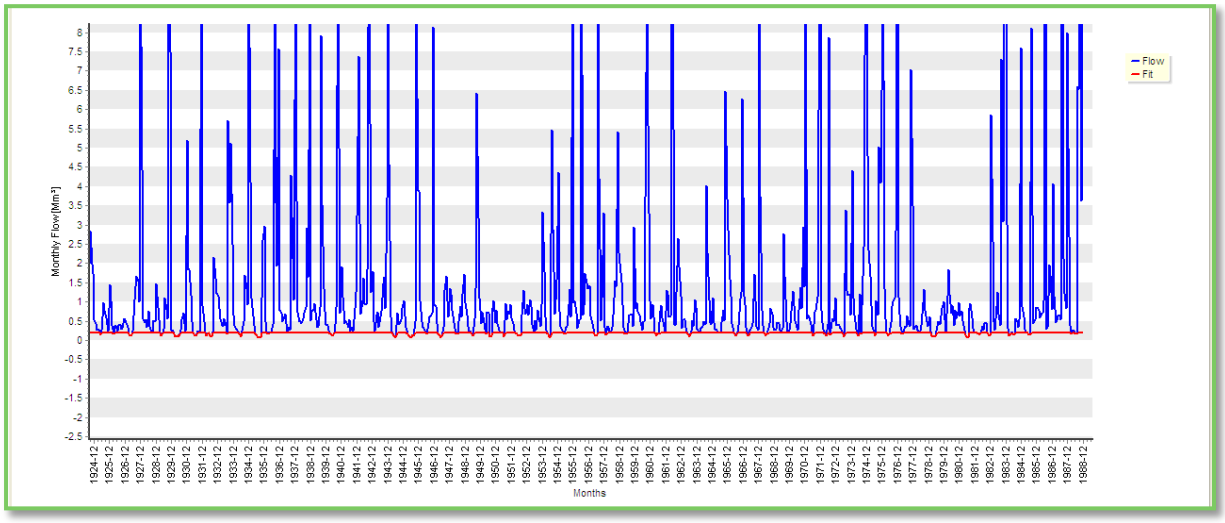


FIGURE C 32: BASEFLOW SEPARATION FOR CATCHMENT W22G

Resource Unit 9

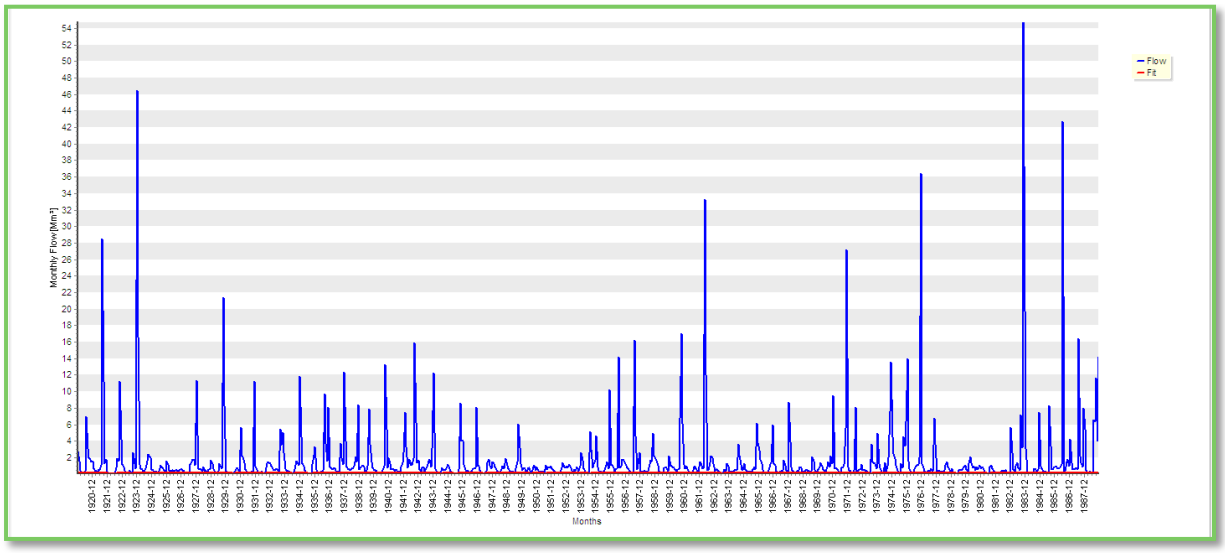


FIGURE C 33: BASEFLOW SEPARATION FOR CATCHMENT W22H

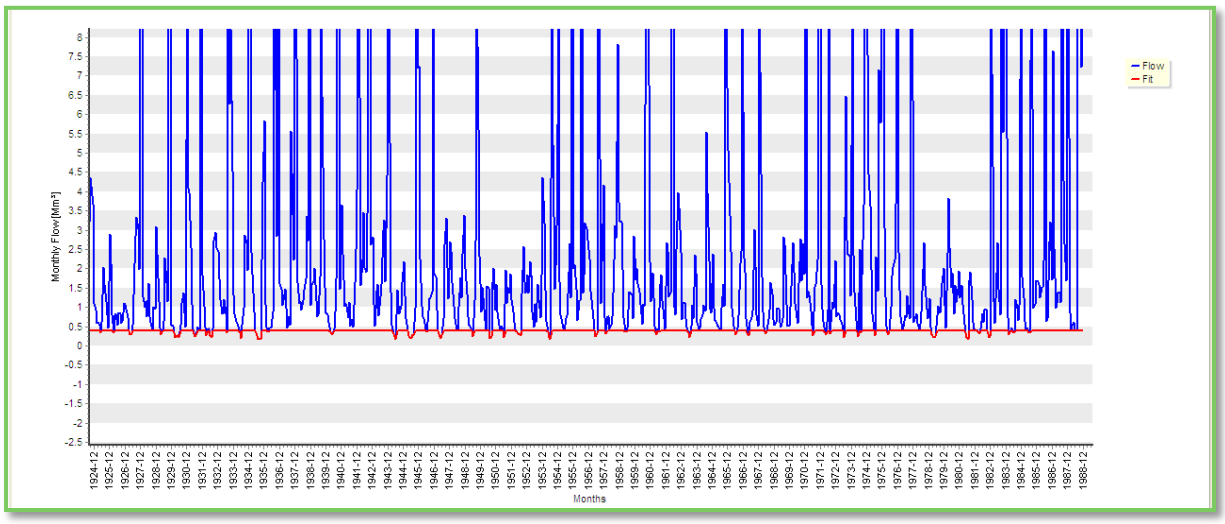


FIGURE C 34: BASEFLOW SEPARATION FOR CATCHMENT W22J

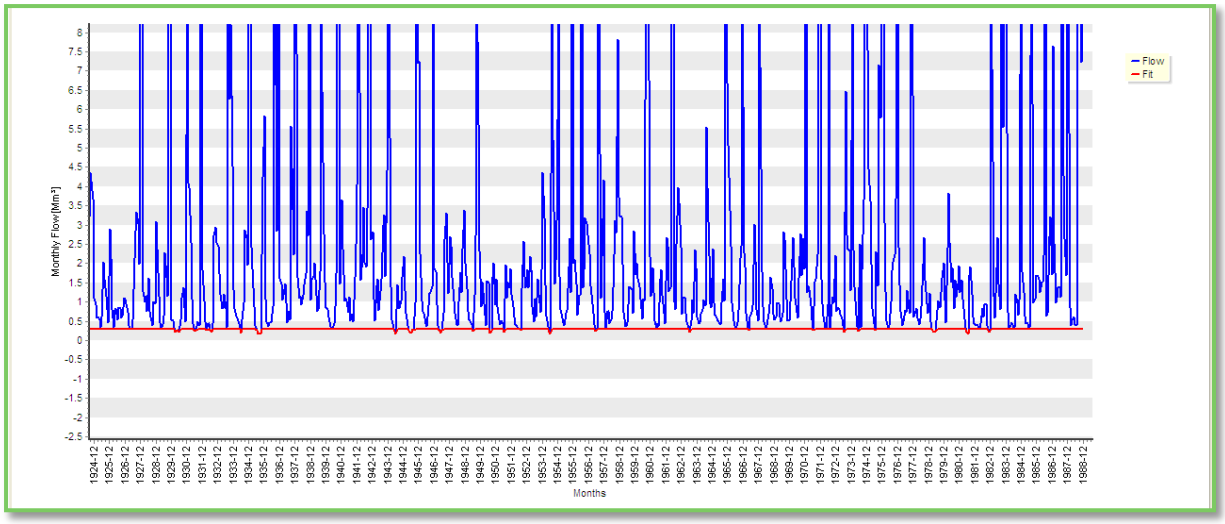


FIGURE C 35: BASEFLOW SEPARATION FOR CATCHMENT W22K

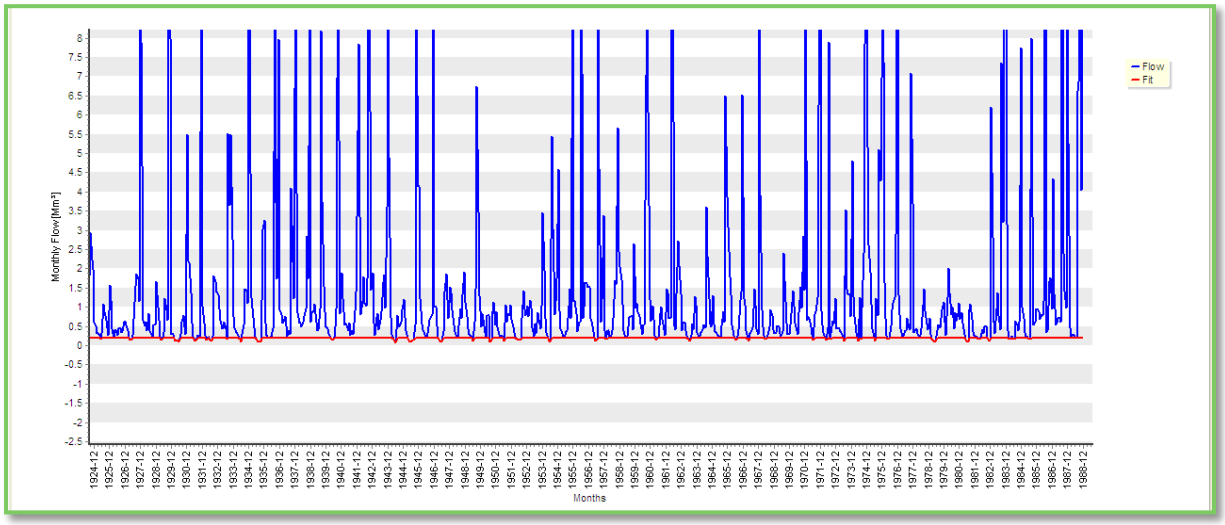


FIGURE C 36: BASEFLOW SEPARATION FOR CATCHMENT W22L

Resource Unit 10

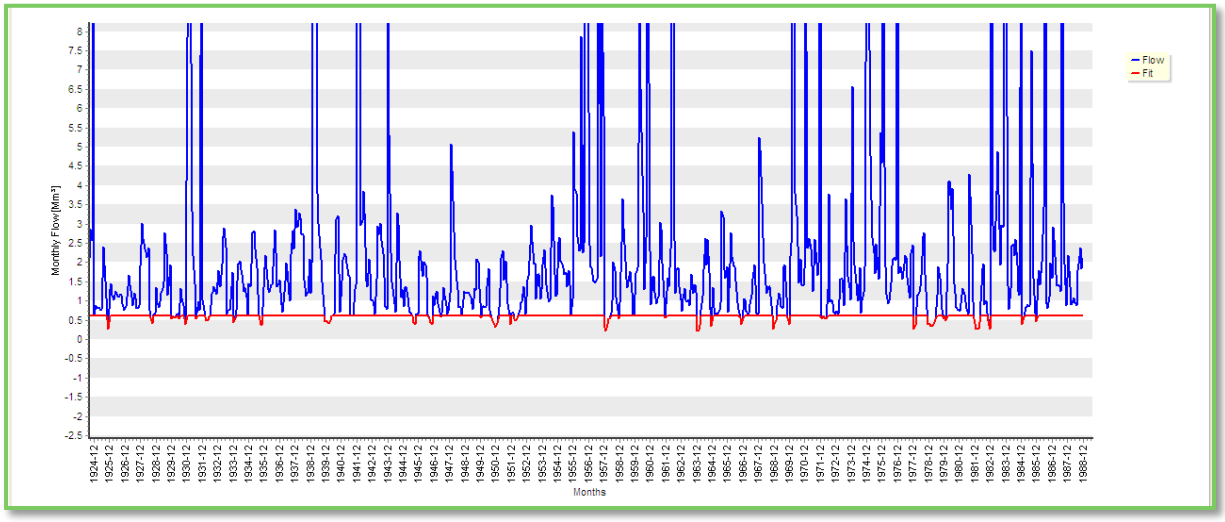


FIGURE C 37: BASEFLOW SEPARATION FOR CATCHMENT W23A

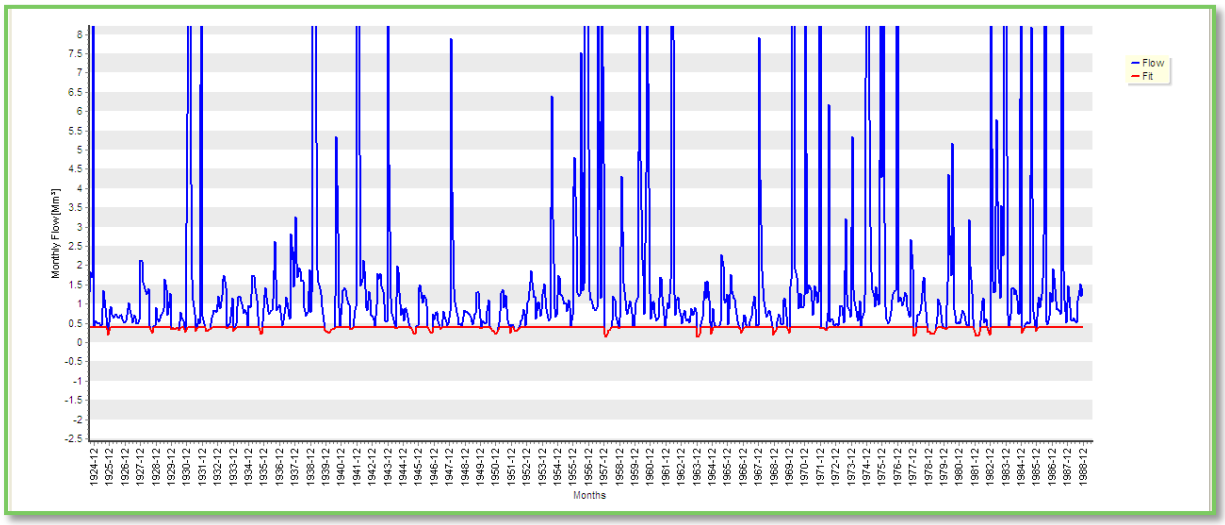


FIGURE C 38: BASEFLOW SEPARATION FOR CATCHMENT W23B

Resource Unit 11

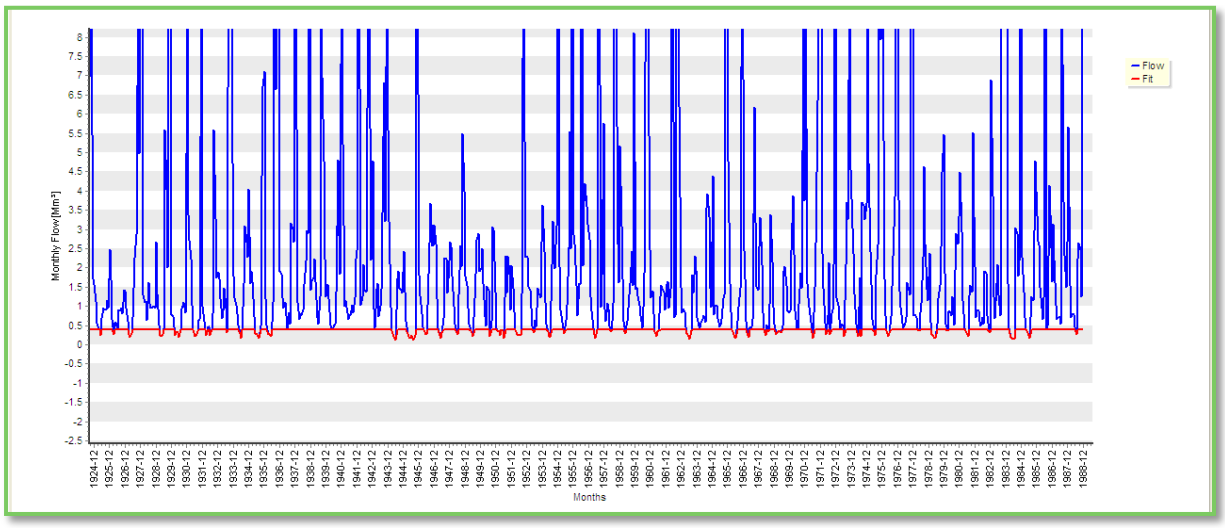


FIGURE C 39: BASEFLOW SEPARATION FOR CATCHMENT W31A

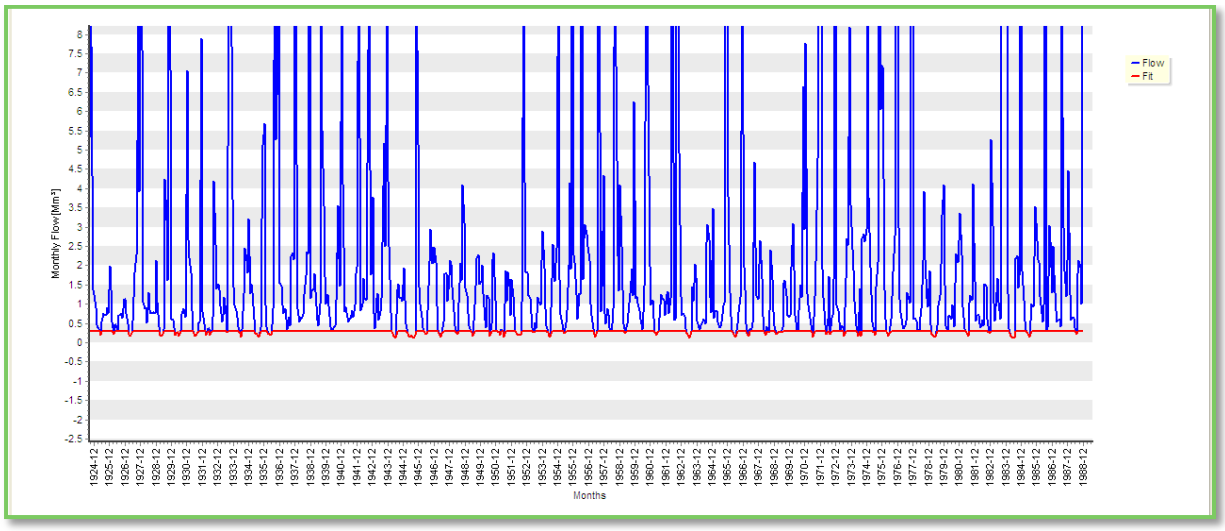


FIGURE C 40: BASEFLOW SEPARATION FOR CATCHMENT W31B

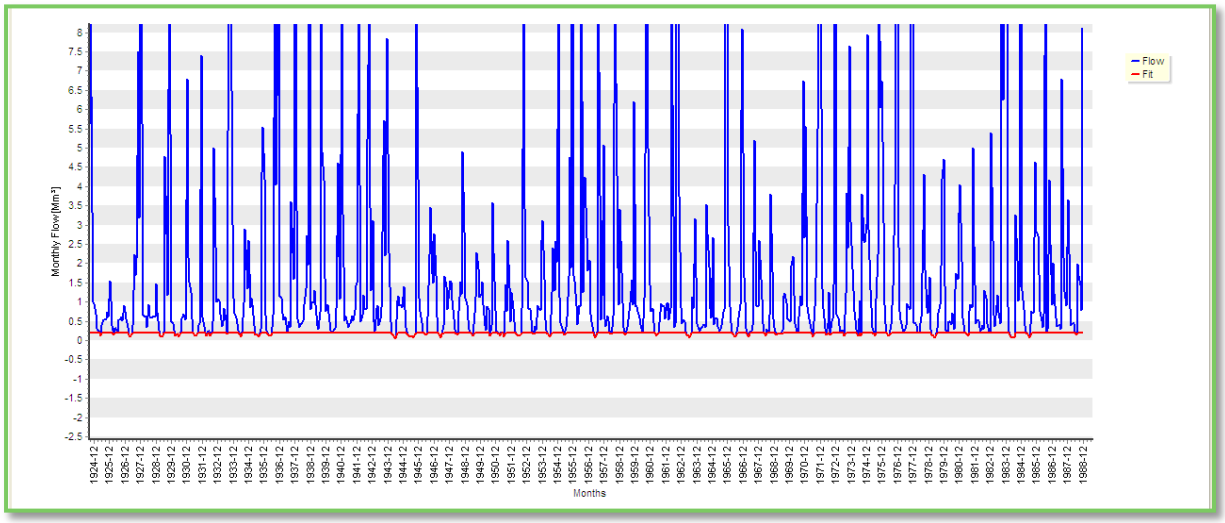


FIGURE C 41: BASEFLOW SEPARATION FOR CATCHMENT W31C

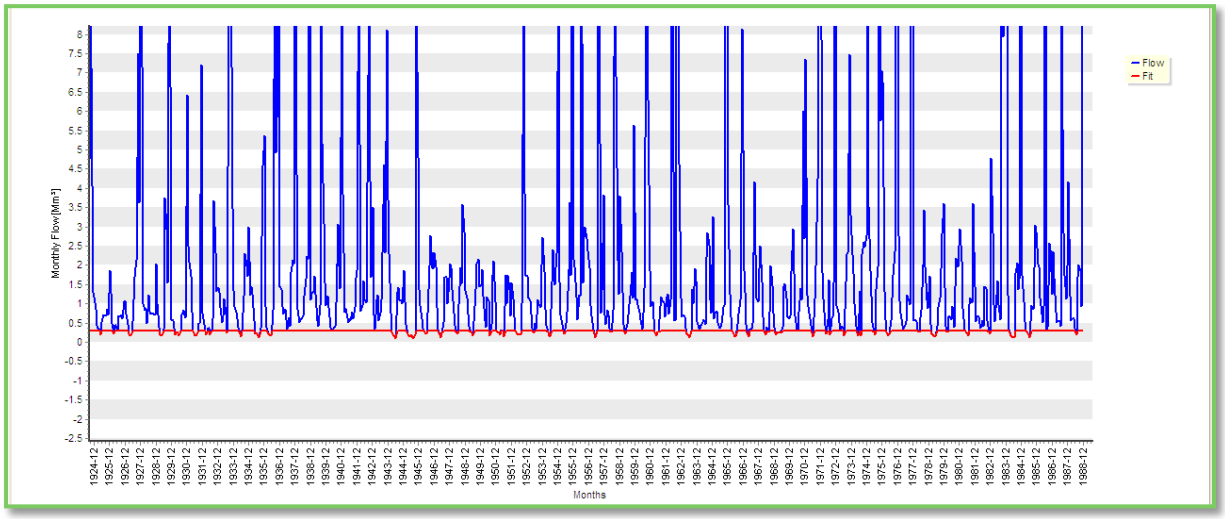


FIGURE C 42: BASEFLOW SEPARATION FOR CATCHMENT W31D

Resource Unit 12

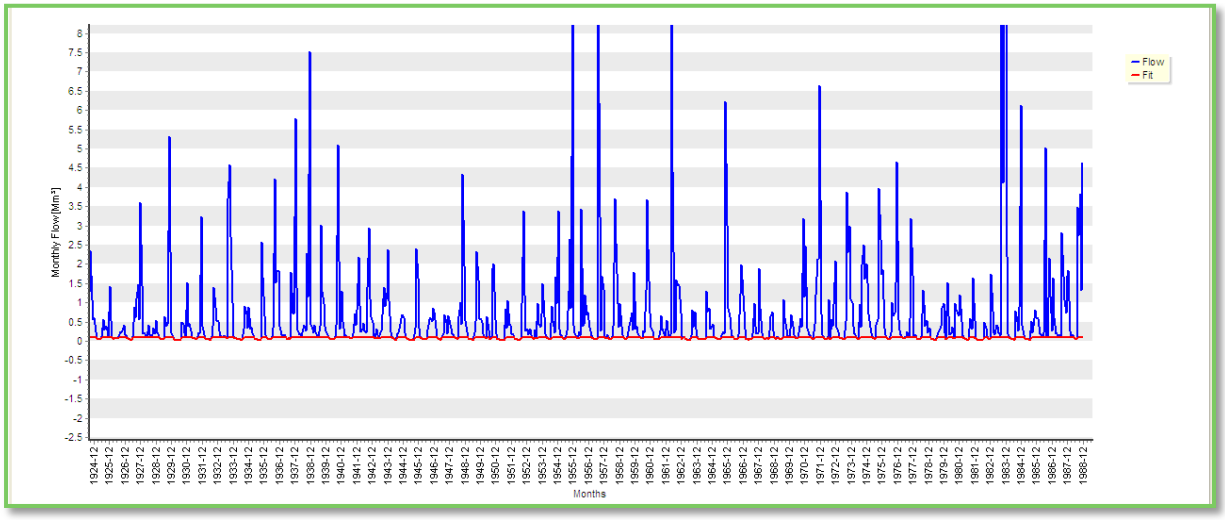


FIGURE C 43: BASEFLOW SEPARATION FOR CATCHMENT W31E

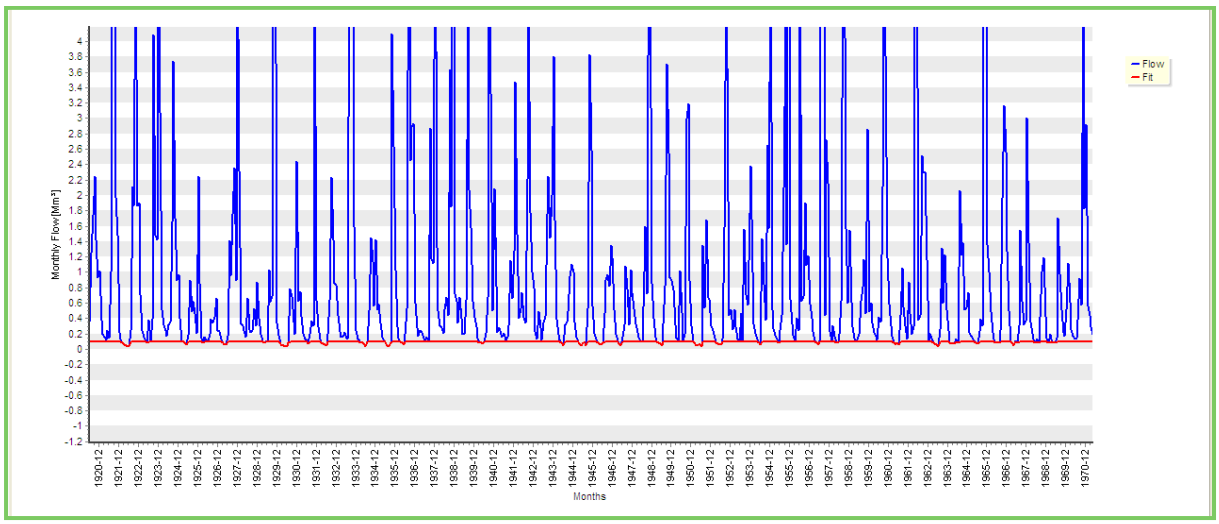


FIGURE C 44: BASEFLOW SEPARATION FOR CATCHMENT W31F

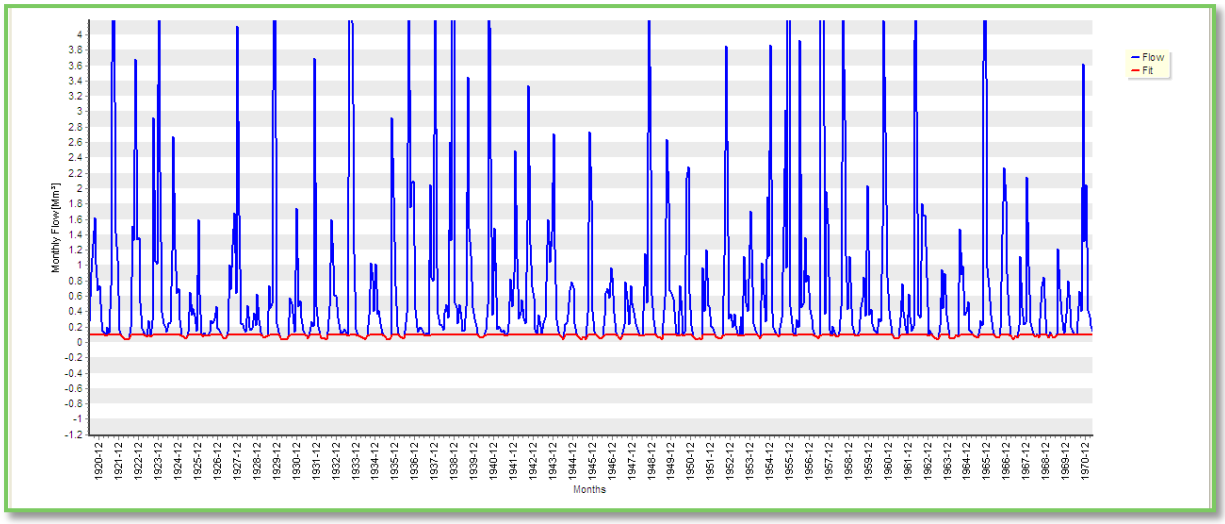


FIGURE C 45: BASEFLOW SEPARATION FOR CATCHMENT W31G

Resource Unit 13

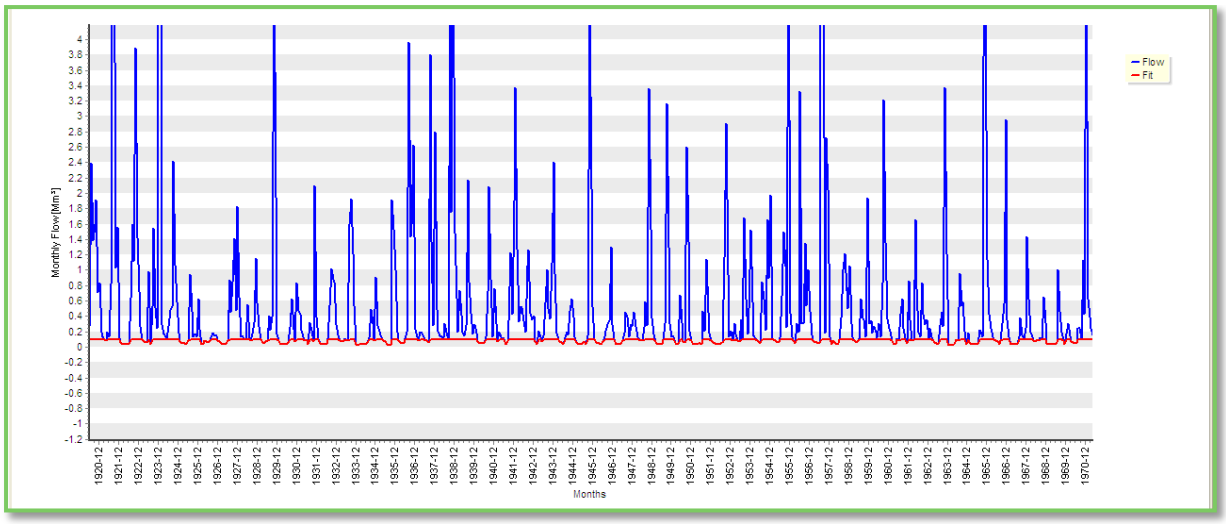


FIGURE C 46: BASEFLOW SEPARATION FOR CATCHMENT W31H

Resource Unit 14

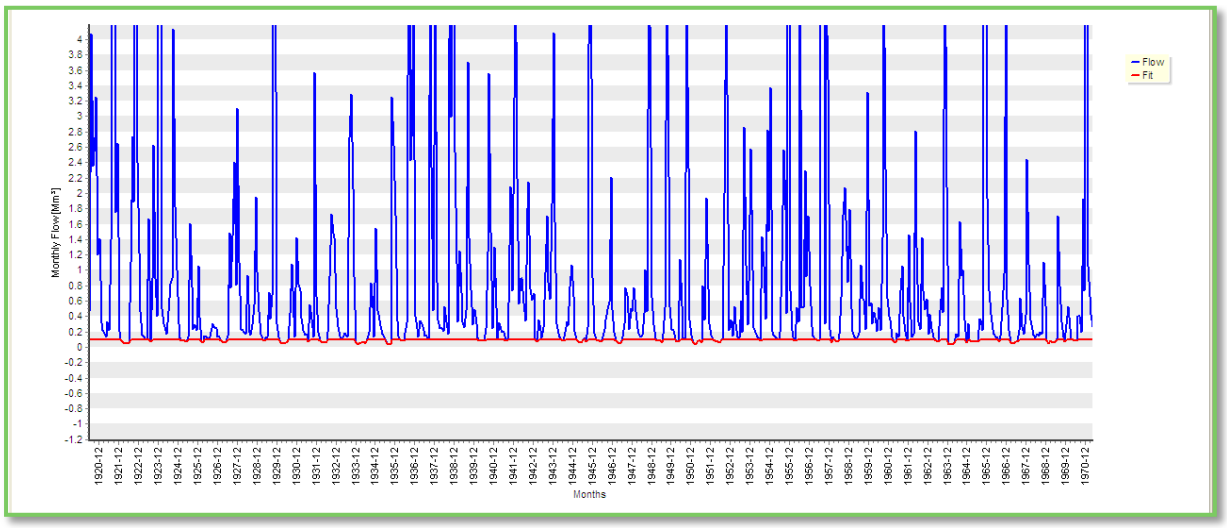


FIGURE C 47: BASEFLOW SEPARATION FOR CATCHMENT W31J

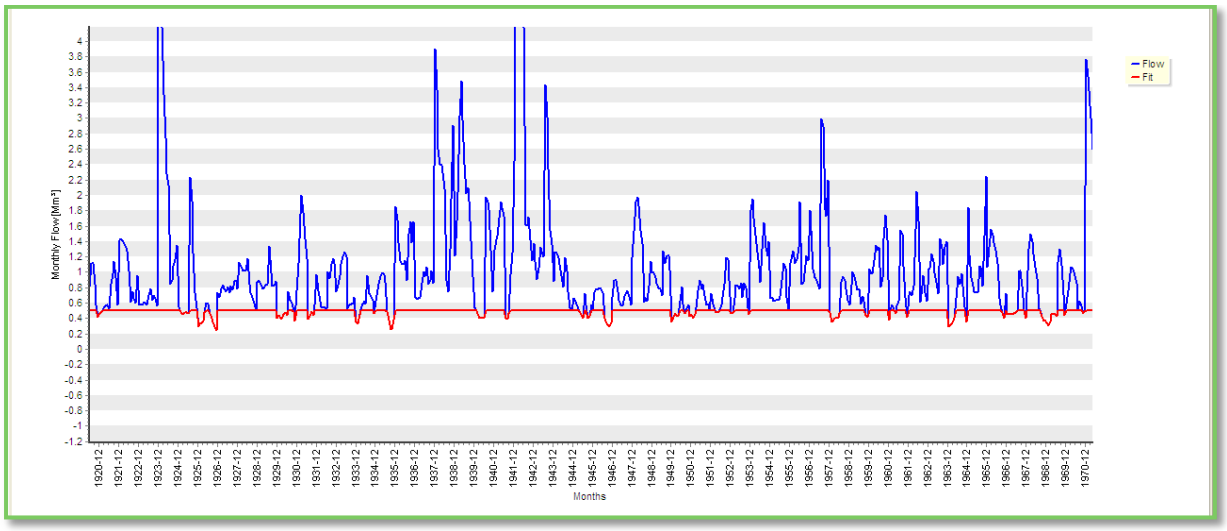


FIGURE C 48: BASEFLOW SEPARATION FOR CATCHMENT W32A

Resource Unit 15

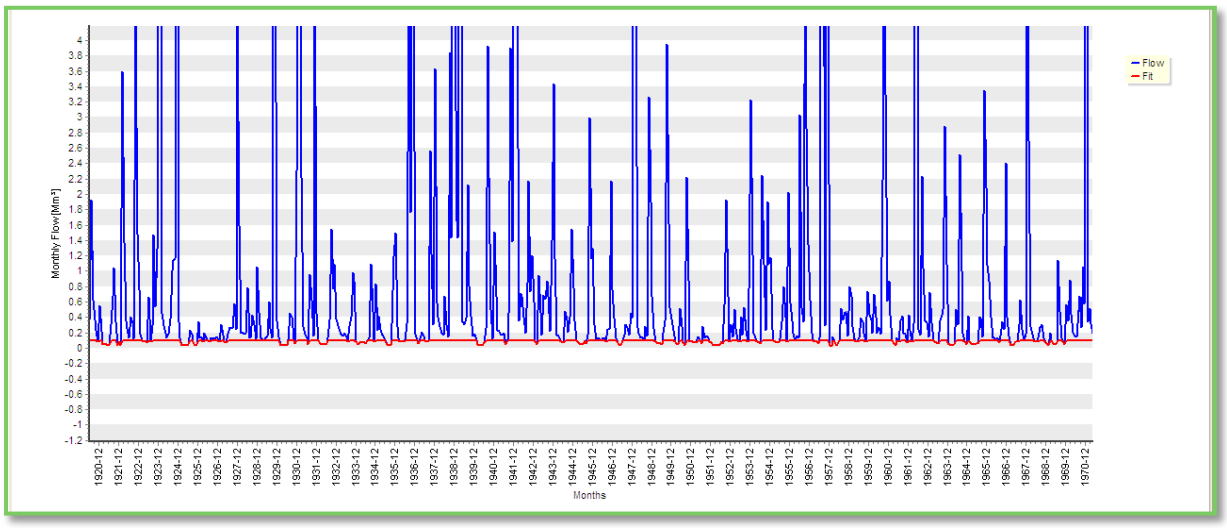


FIGURE C 49: BASEFLOW SEPARATION FOR CATCHMENT W32D

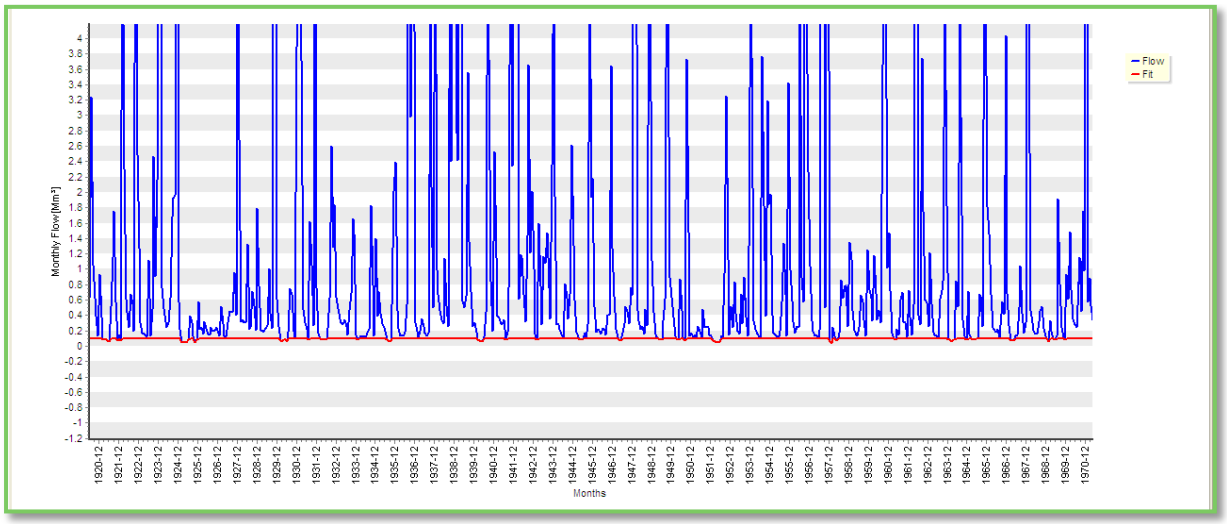


FIGURE C 50: BASEFLOW SEPARATION FOR CATCHMENT W32E

Resource Unit 16

No data available.

Resource Unit 17

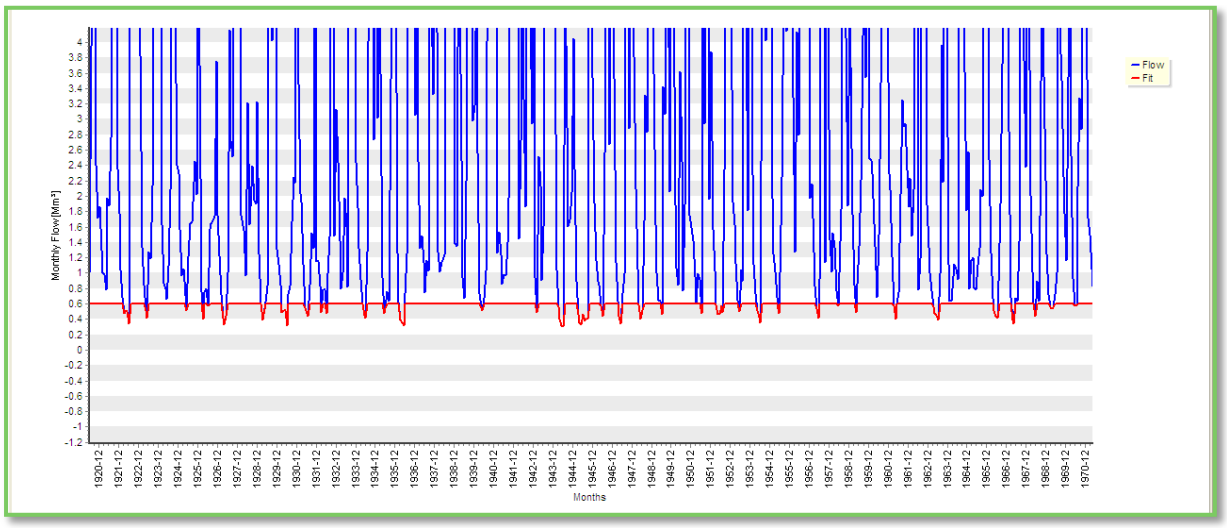


FIGURE C 51: BASEFLOW SEPARATION FOR CATCHMENT W41A

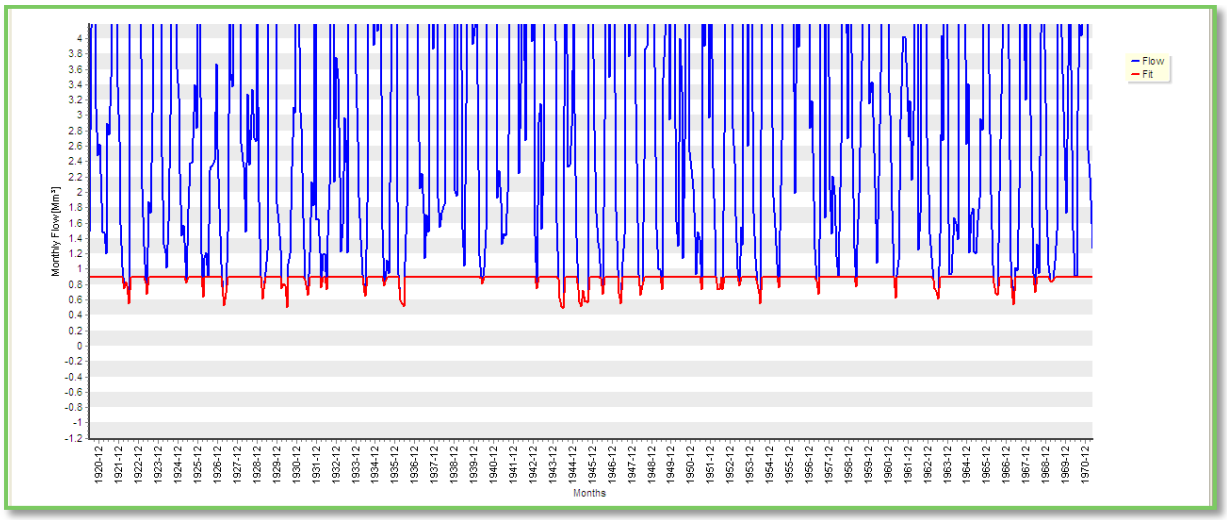


FIGURE C 52: BASEFLOW SEPARATION FOR CATCHMENT W41B

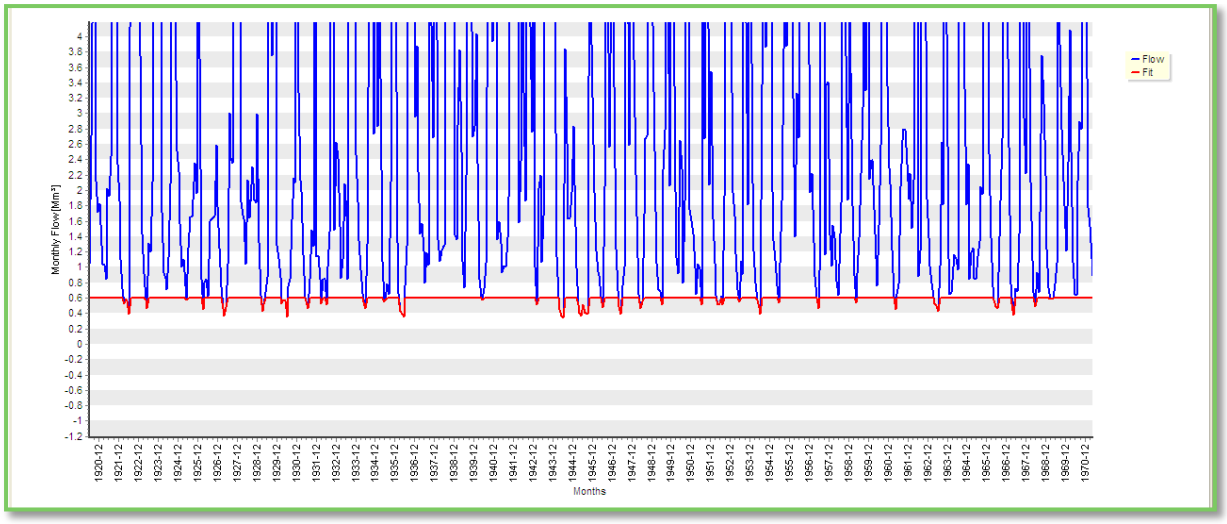


FIGURE C 53: BASEFLOW SEPARATION FOR CATCHMENT W41C

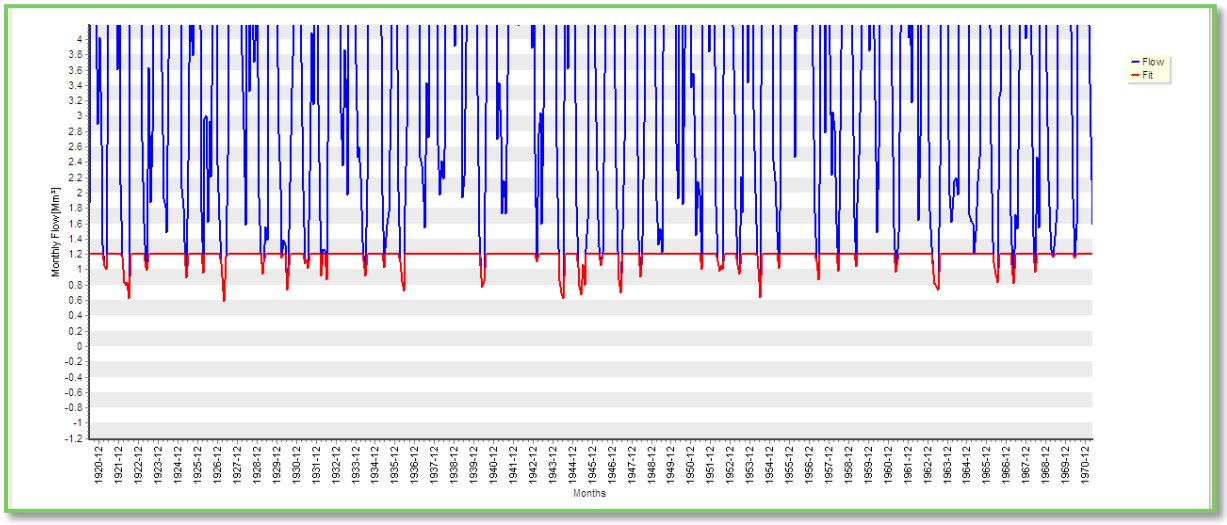


FIGURE C 54: BASEFLOW SEPARATION FOR CATCHMENT W42A

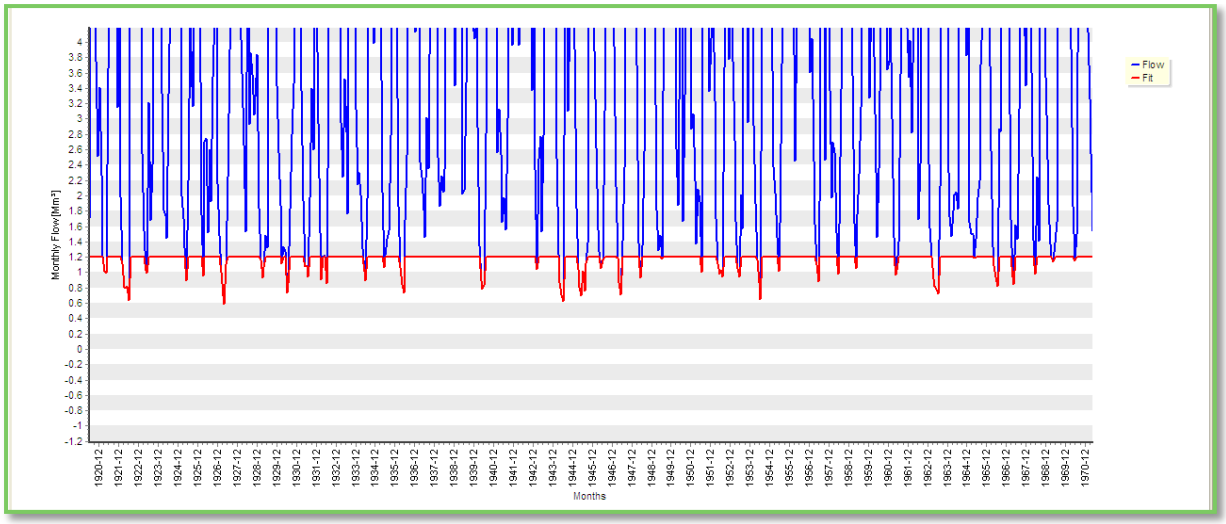


FIGURE C 55: BASEFLOW SEPARATION FOR CATCHMENT W42B

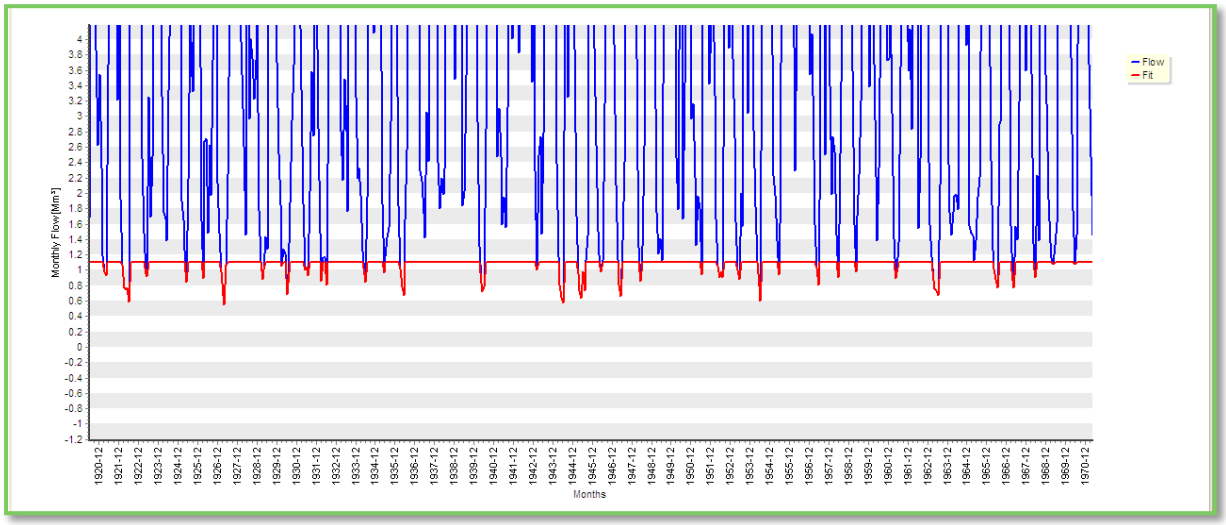


FIGURE C 56: BASEFLOW SEPARATION FOR CATCHMENT W42C

Resource Unit 18

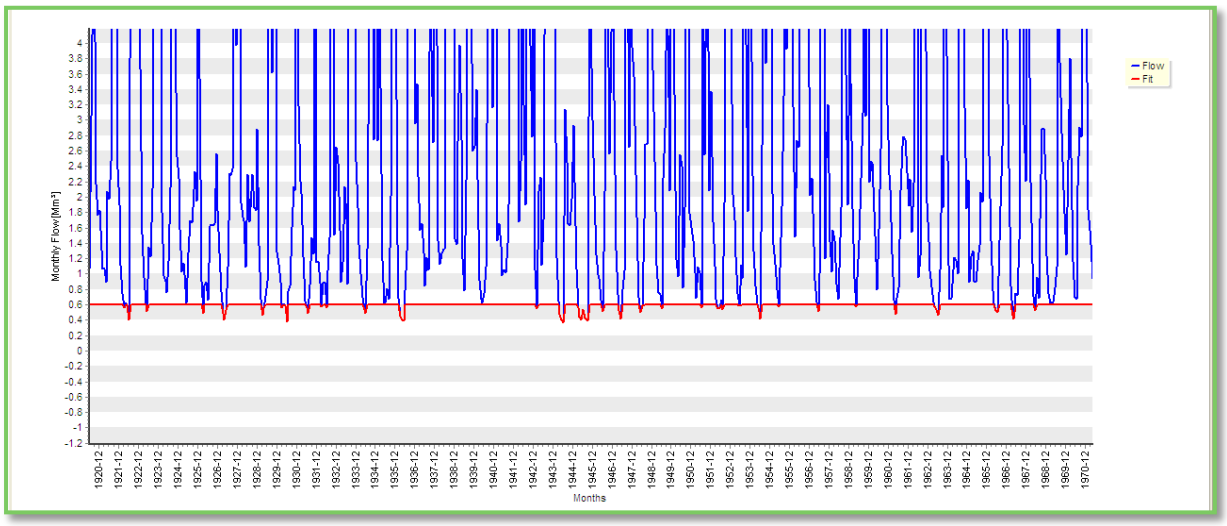


FIGURE C 57: BASEFLOW SEPARATION FOR CATCHMENT W41D

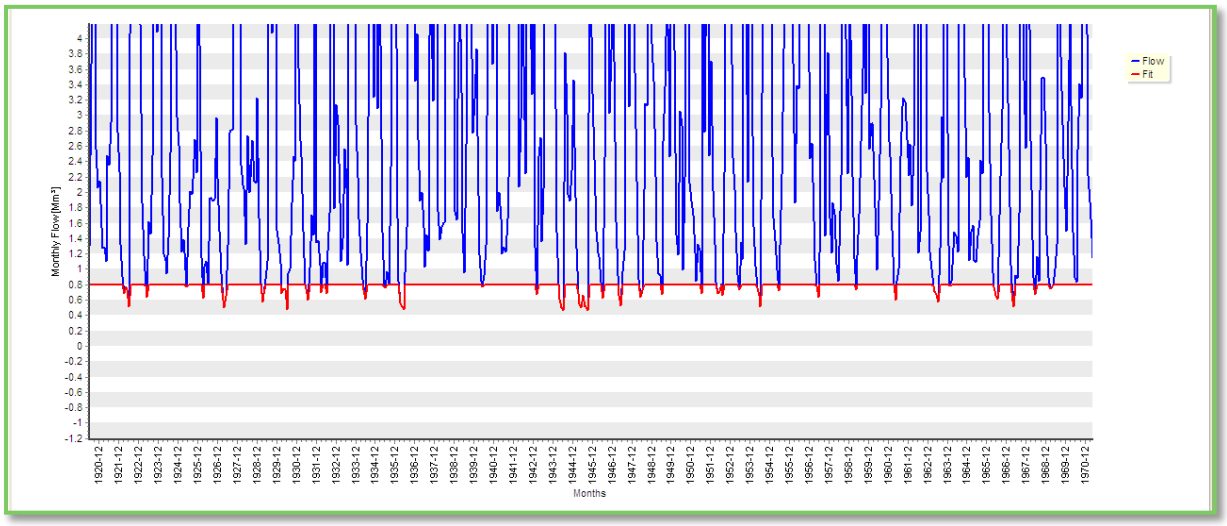


FIGURE C 58: BASEFLOW SEPARATION FOR CATCHMENT W41E

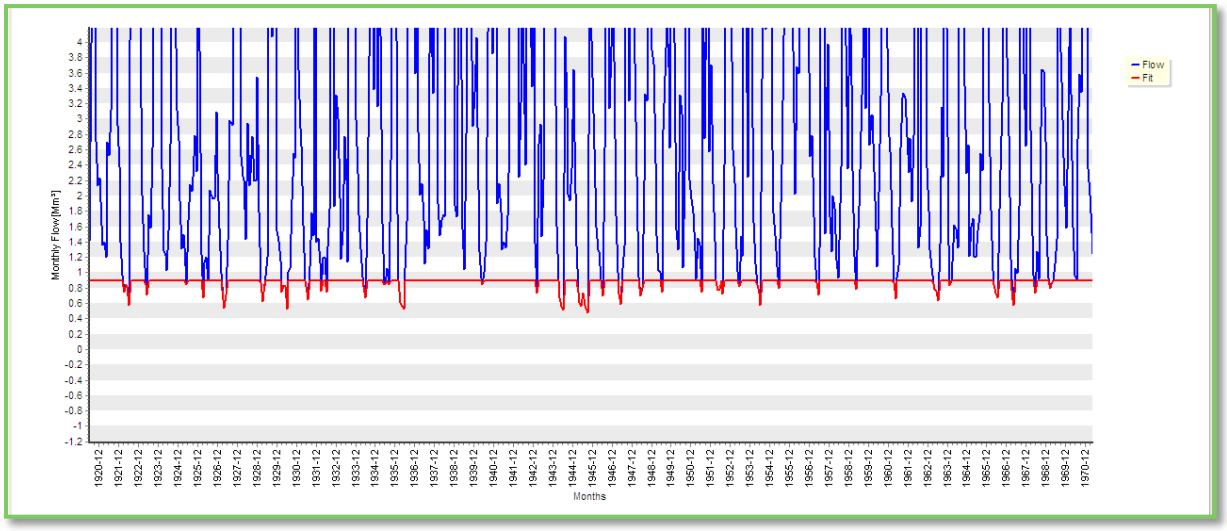


FIGURE C 59: BASEFLOW SEPARATION FOR CATCHMENT W41F

Resource Unit 19

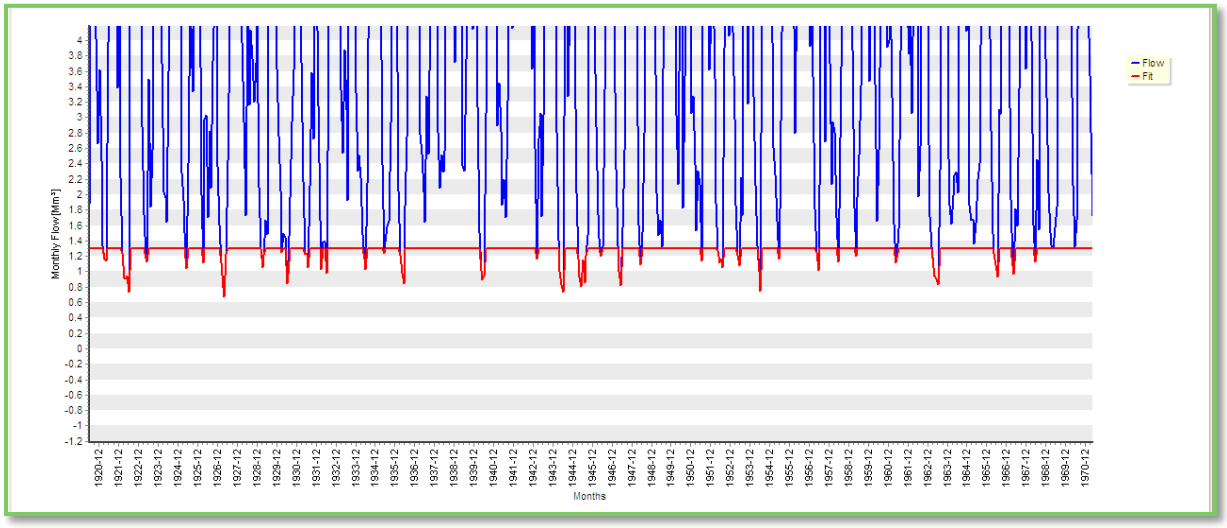


FIGURE C 60: BASEFLOW SEPARATION FOR CATCHMENT W42D

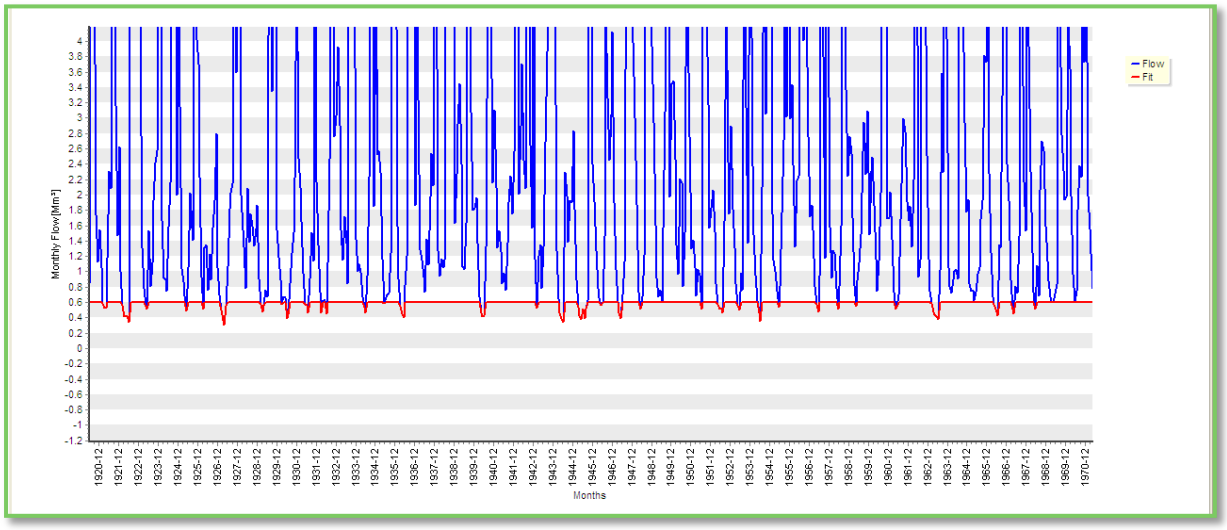


FIGURE C 61: BASEFLOW SEPARATION FOR CATCHMENT W42E

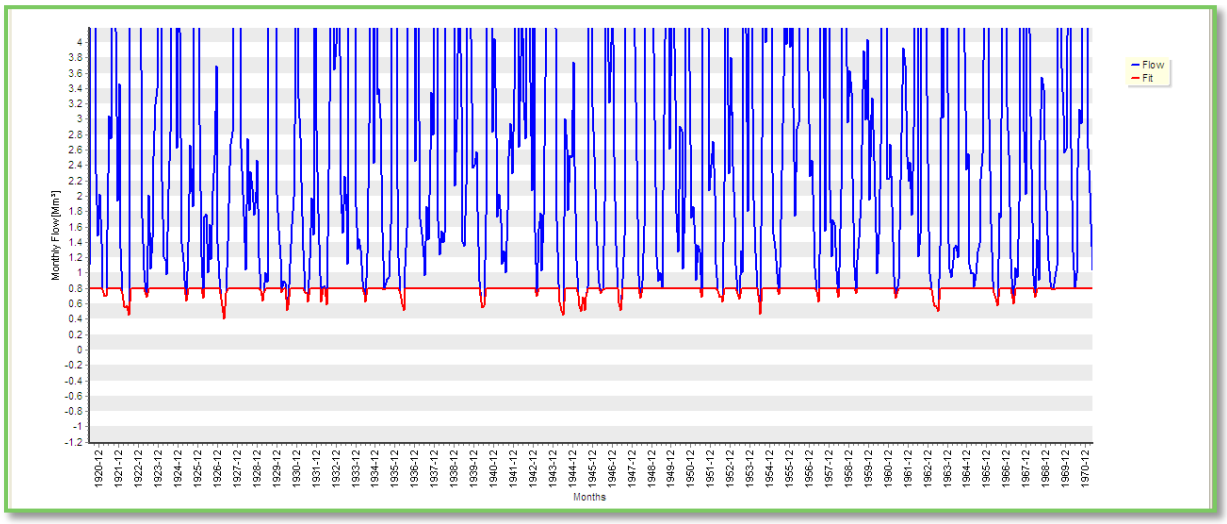


FIGURE C 62: BASEFLOW SEPARATION FOR CATCHMENT W42F

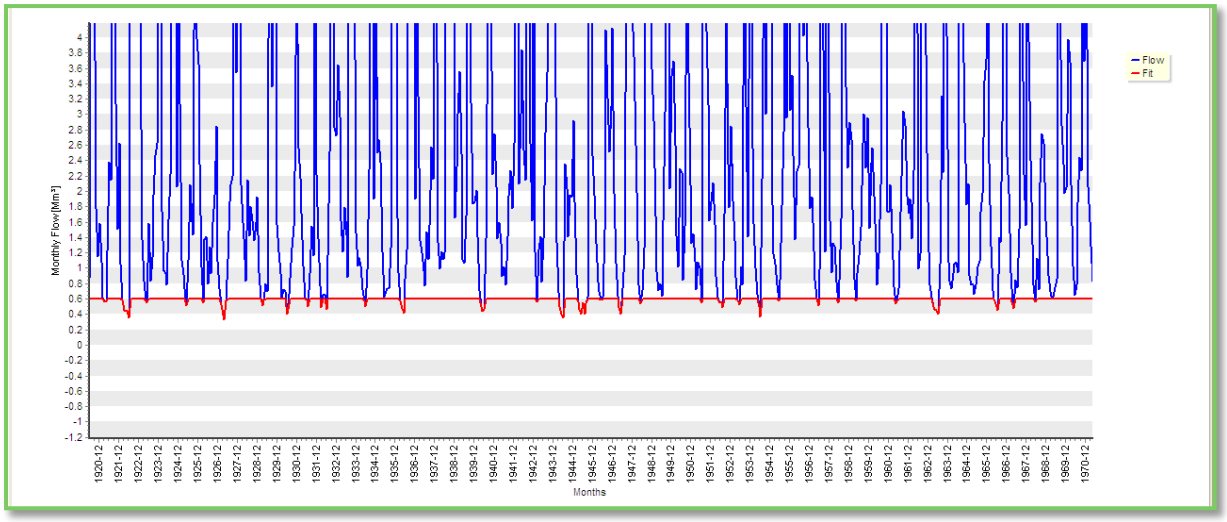


FIGURE C 63: BASEFLOW SEPARATION FOR CATCHMENT W42G

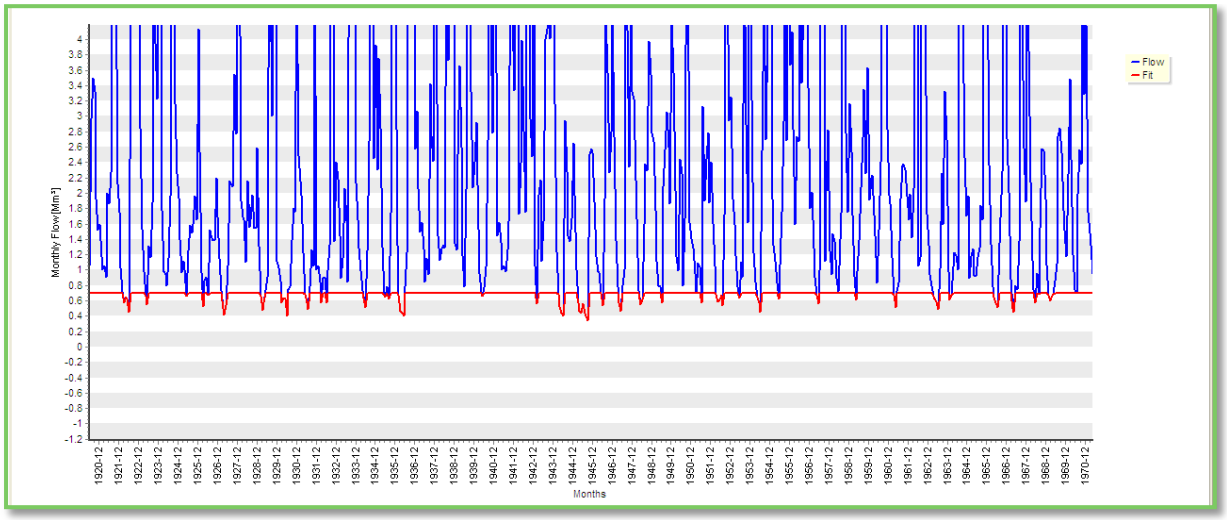


FIGURE C 64: BASEFLOW SEPARATION FOR CATCHMENT W42H

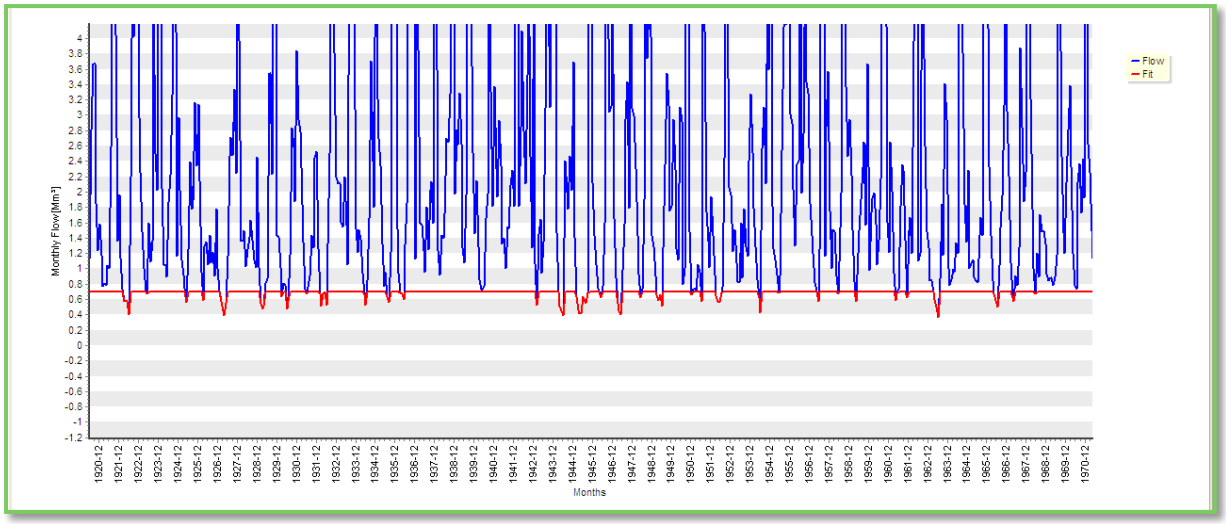


FIGURE C 65: BASEFLOW SEPARATION FOR CATCHMENT W42J

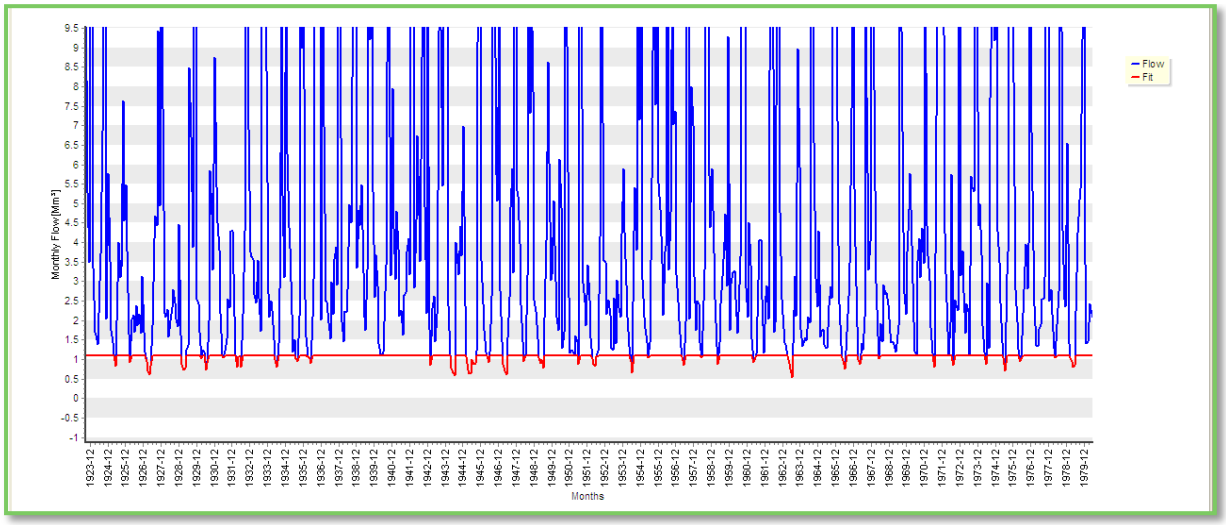


FIGURE C 66: BASEFLOW SEPARATION FOR CATCHMENT W42K

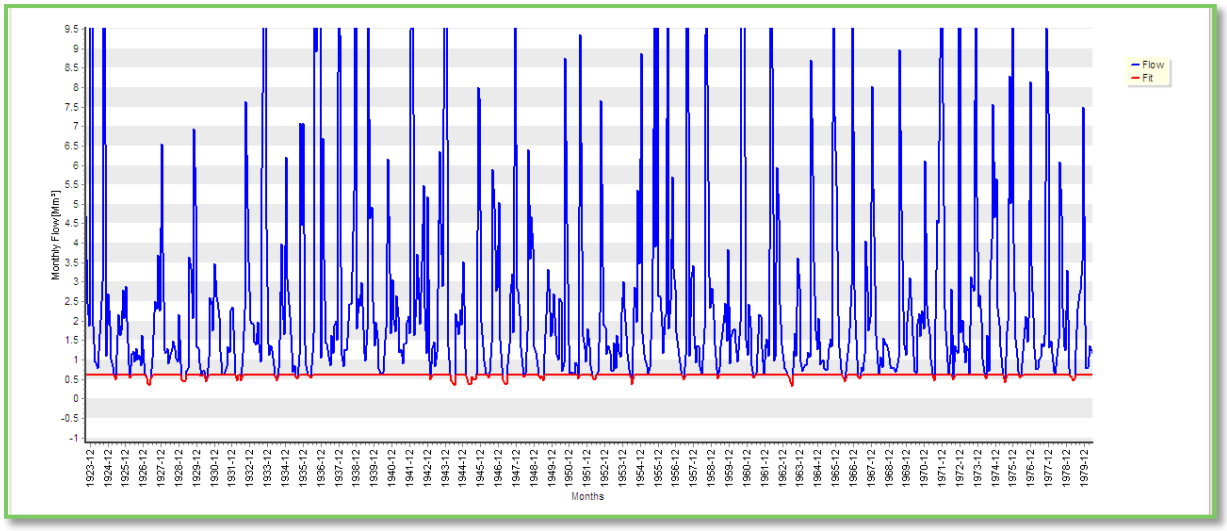


FIGURE C 67: BASEFLOW SEPARATION FOR CATCHMENT W42L

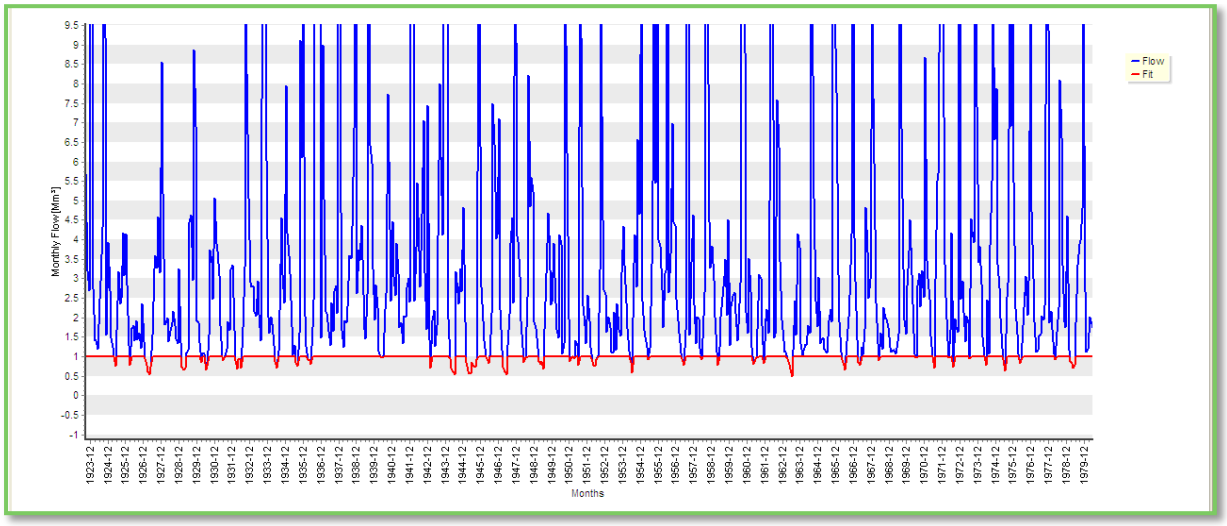


FIGURE C 68: BASEFLOW SEPARATION FOR CATCHMENT W42M

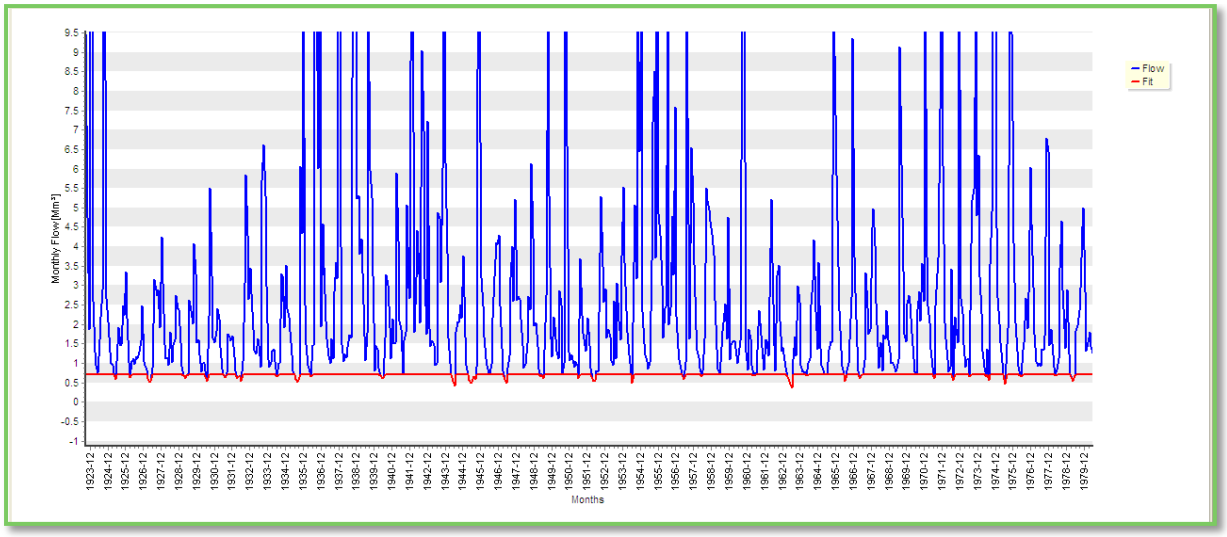


FIGURE C 69: BASEFLOW SEPARATION FOR CATCHMENT W43A

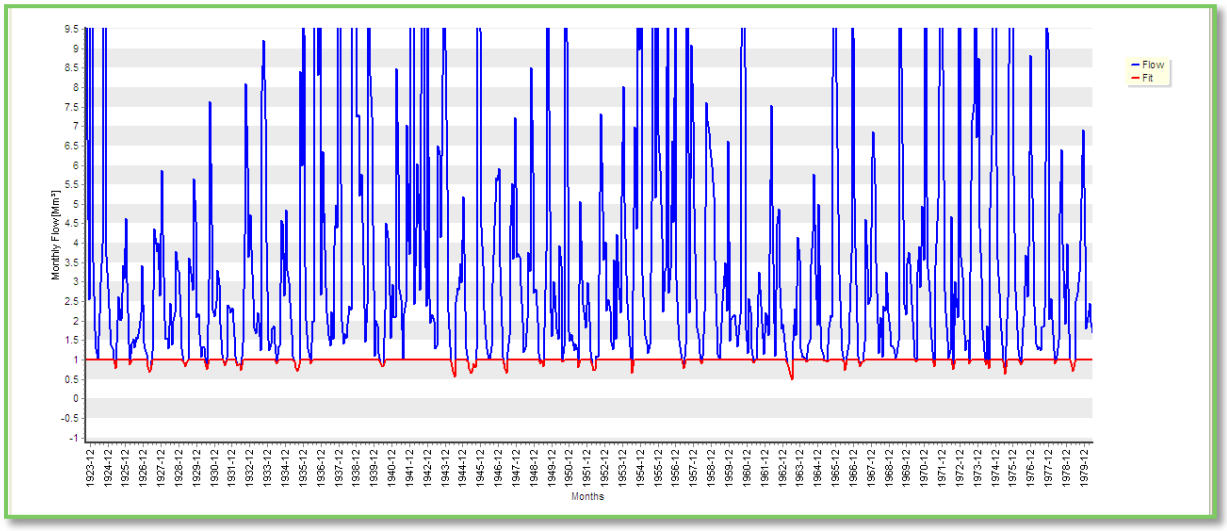


FIGURE C 70: BASEFLOW SEPARATION FOR CATCHMENT W43B

Resource Unit 20

No data available.

Resource Unit 21

No data available.

Resource Unit 22

No data available.

Resource Unit 23

No data available.

Resource Unit 24
No data available.

Resource Unit 25
No data available.

Resource Unit 26
No data available.

Resource Unit 27
No data available.

Resource Unit 28
No data available.

Resource Unit 29
No data available.

A note on the baseflow calculations
Only 66% of the quaternaries within the study area have flow data. To estimate the groundwater contribution to baseflow for the quaternaries with no flow data, correlations between the fitted data and other available figures were determined. The best correlation was obtained with the Pitman values as shown in **Figure C71**. Based on this correlation result it was decided to directly use the Pitman values for quaternaries that had no flow data available.

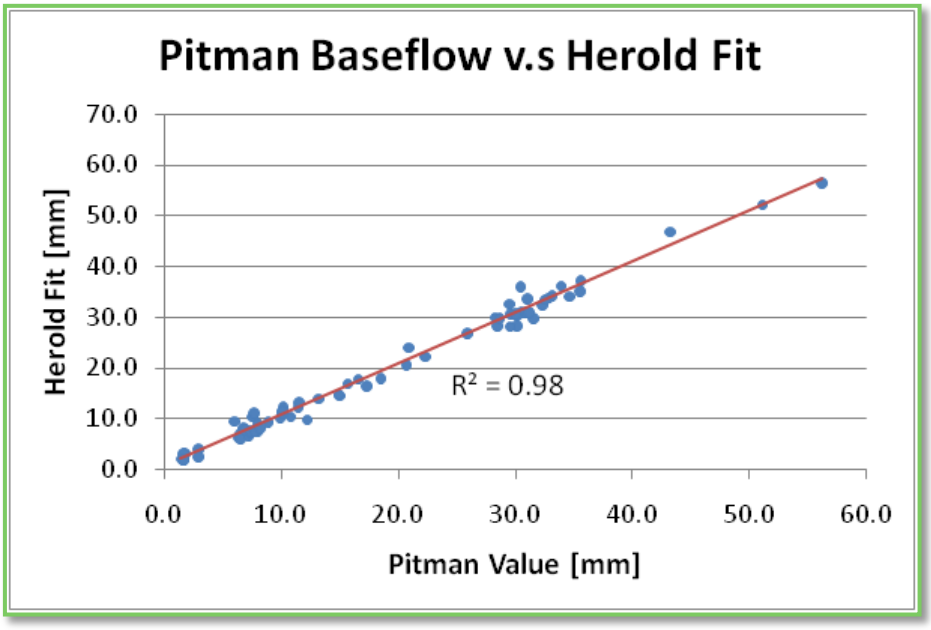


FIGURE C 71: CORRELATION

APPENDIX D: SLOPE HISTOGRAMS

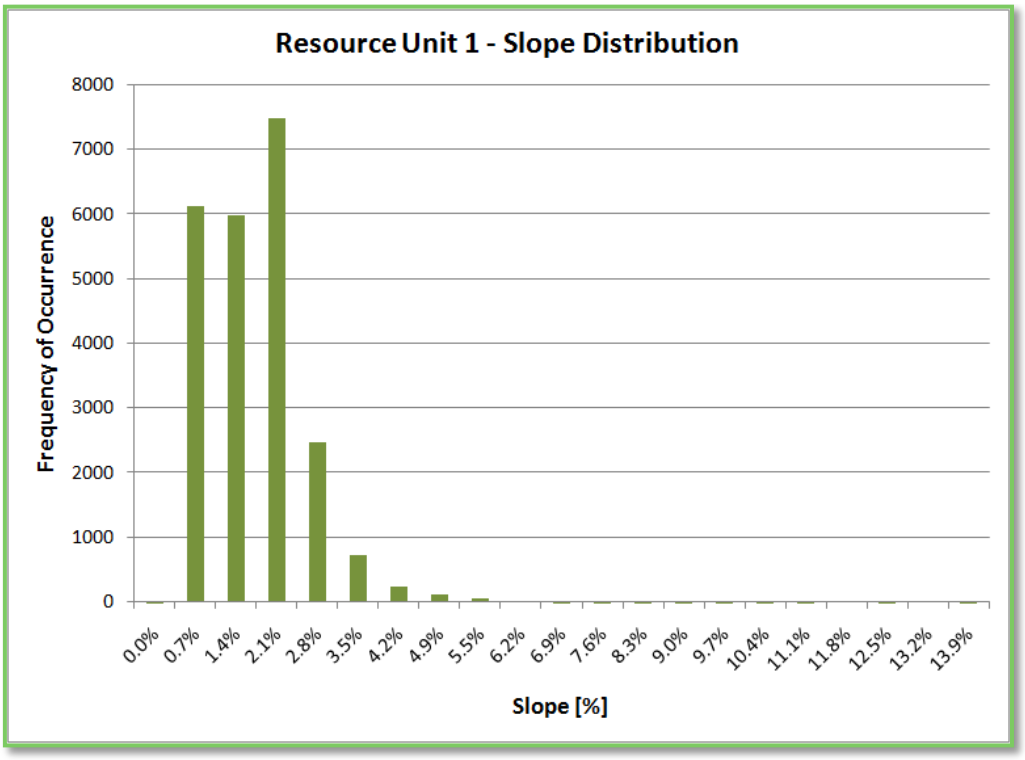


FIGURE D 1: SLOPE HISTOGRAM FOR RU1

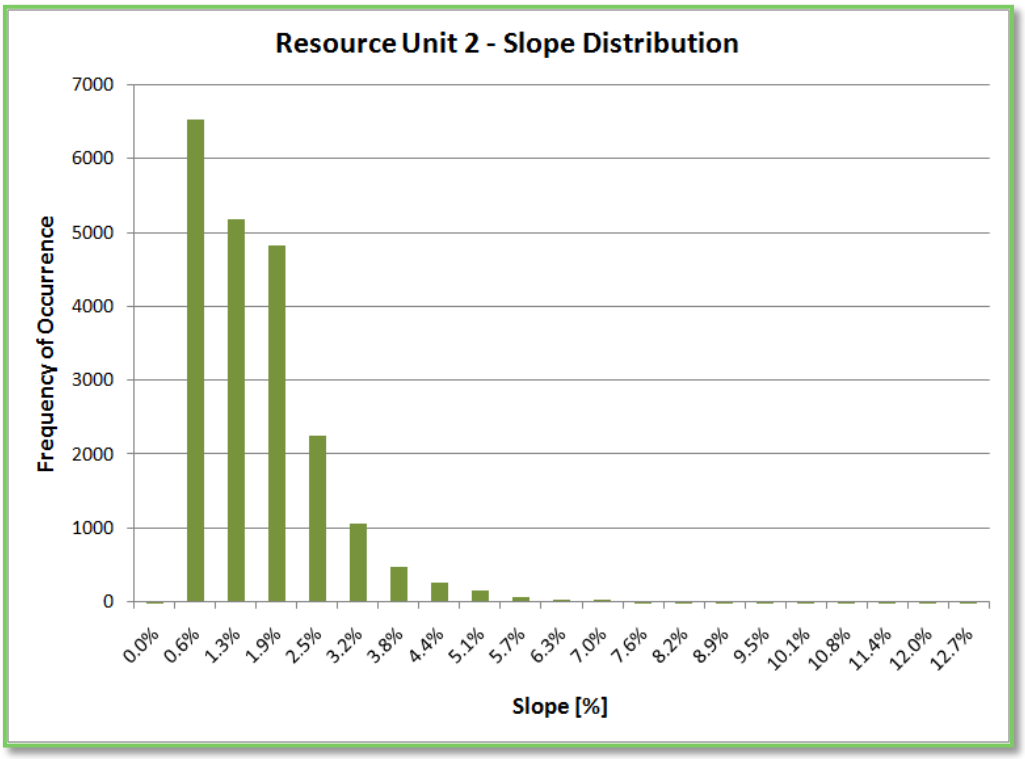


FIGURE D 2: SLOPE HISTOGRAM FOR RU2

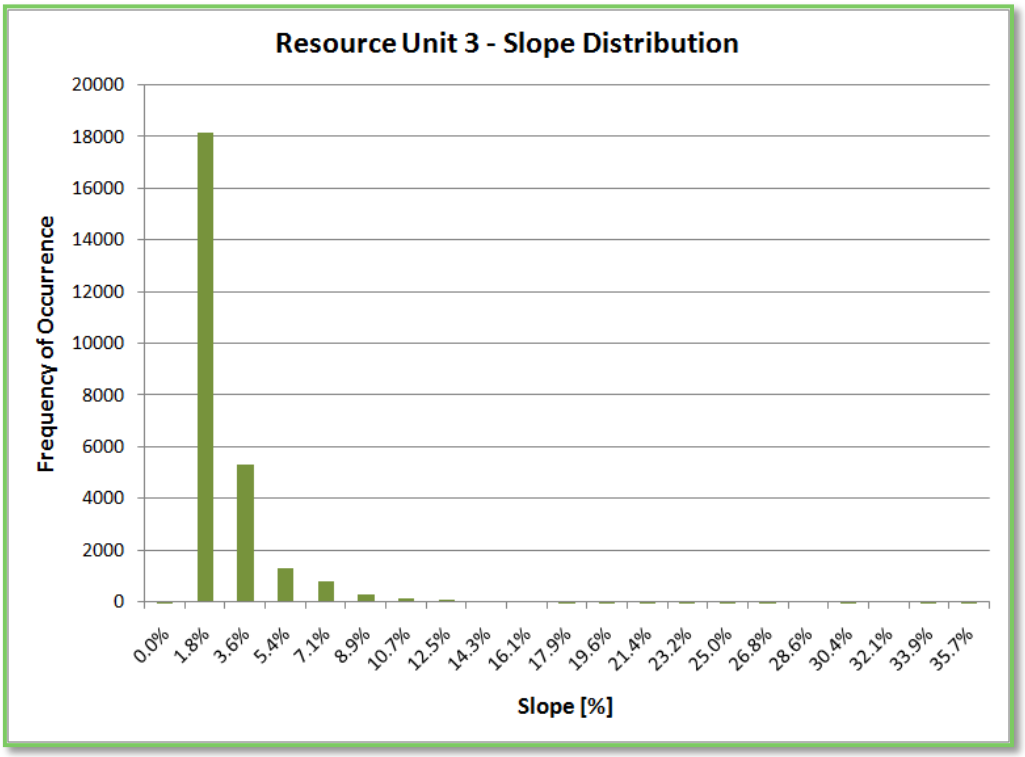


FIGURE D 3: SLOPE HISTOGRAM FOR RU3

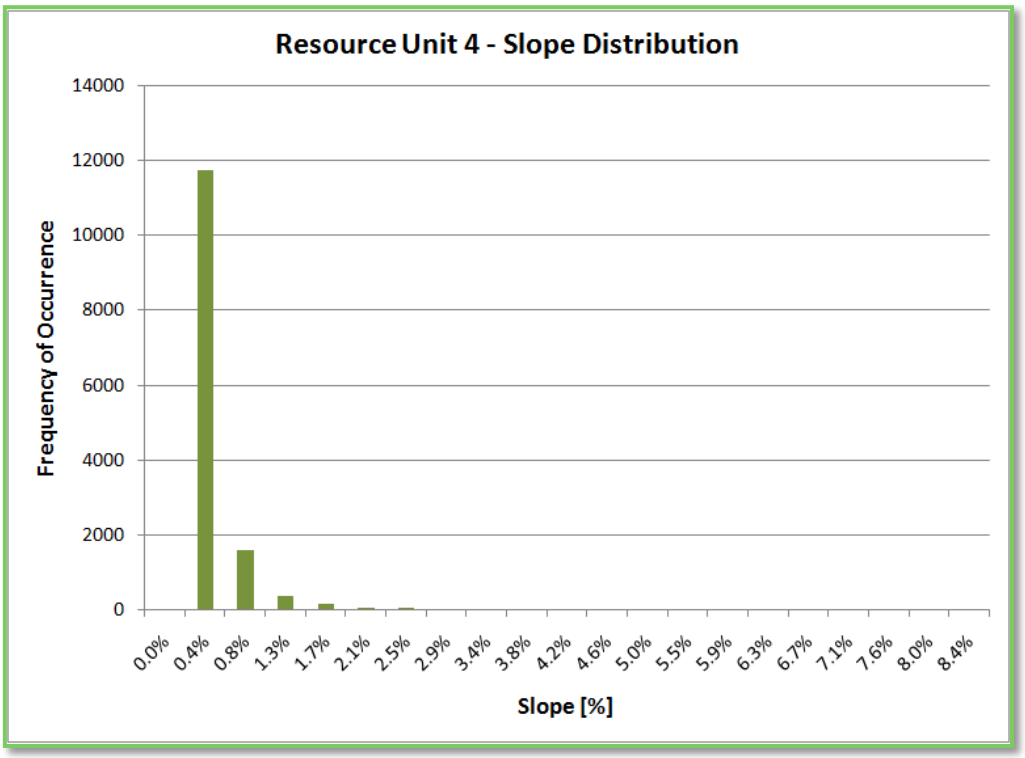


FIGURE D 4: SLOPE HISTOGRAM FOR RU4

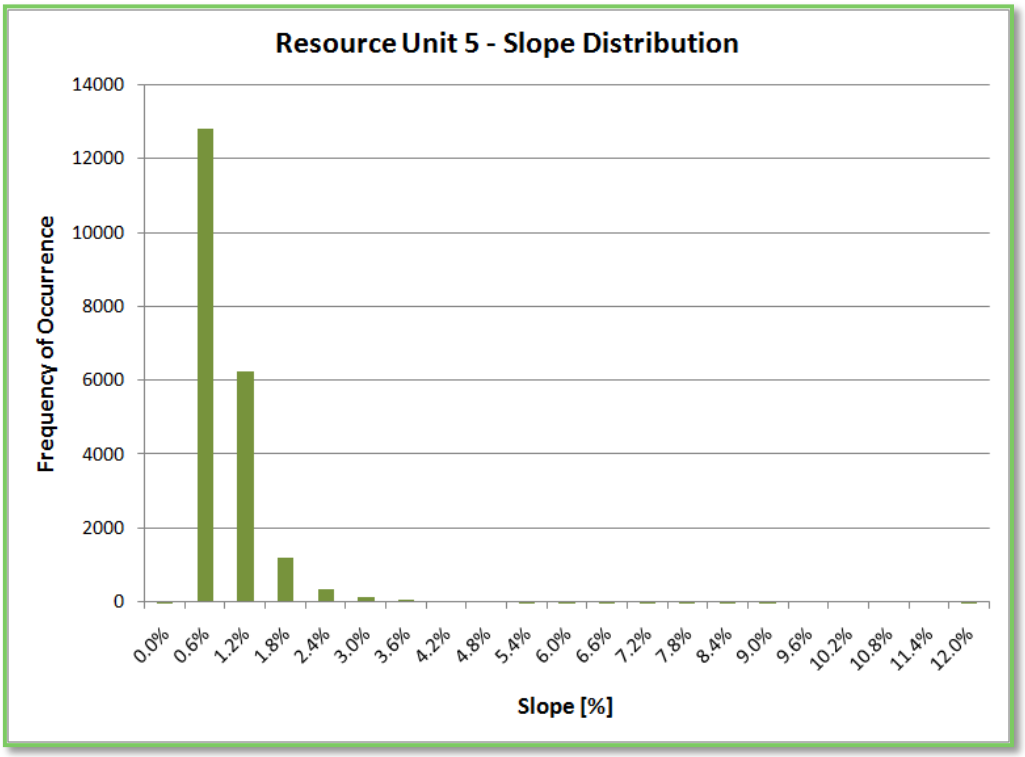


FIGURE D 5: SLOPE HISTOGRAM FOR RU5

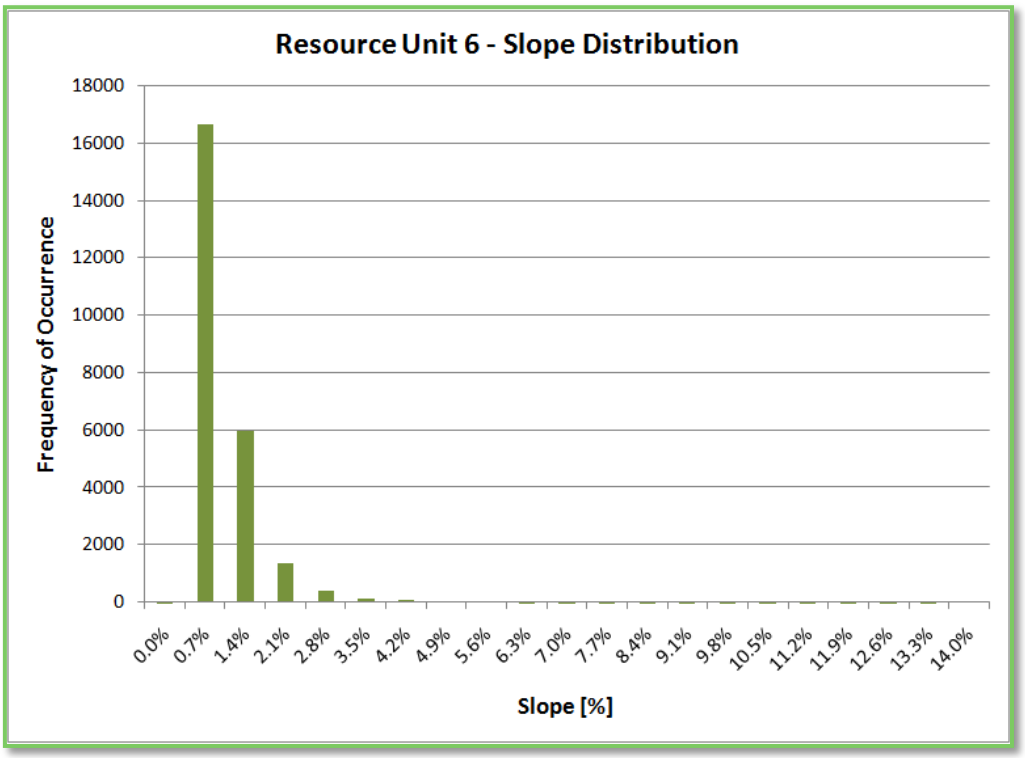


FIGURE D 6: SLOPE HISTOGRAM FOR RU6

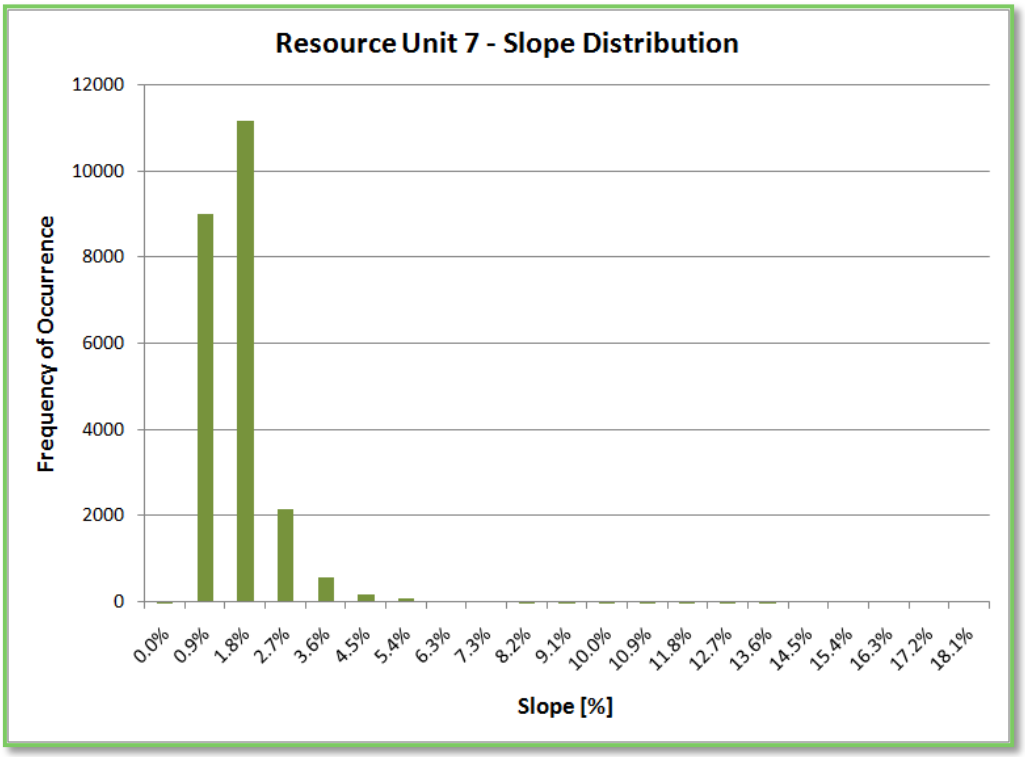


FIGURE D 7: SLOPE HISTOGRAM FOR RU7

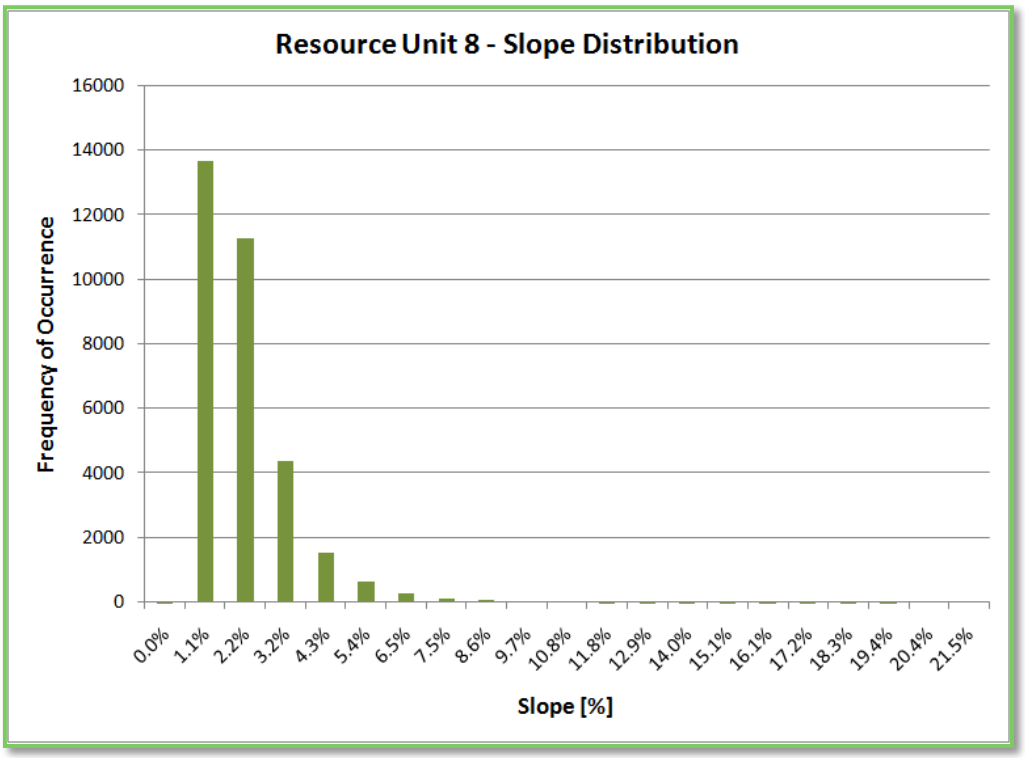


FIGURE D 8: SLOPE HISTOGRAM FOR RU8

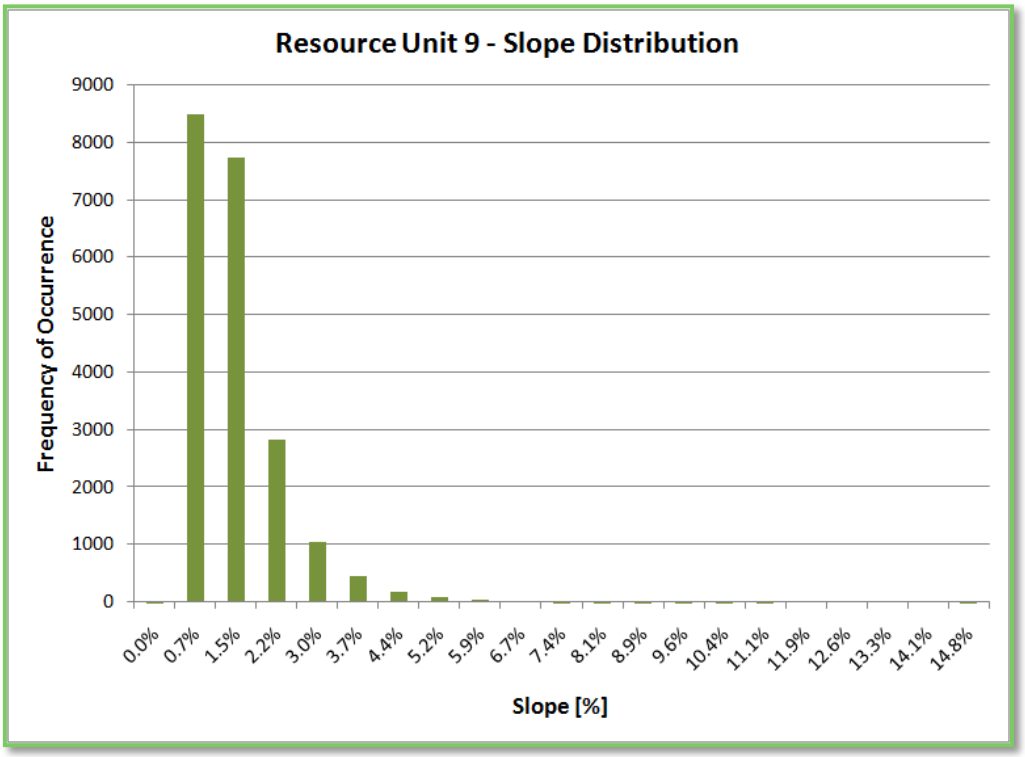


FIGURE D 9: SLOPE HISTOGRAM FOR RU9

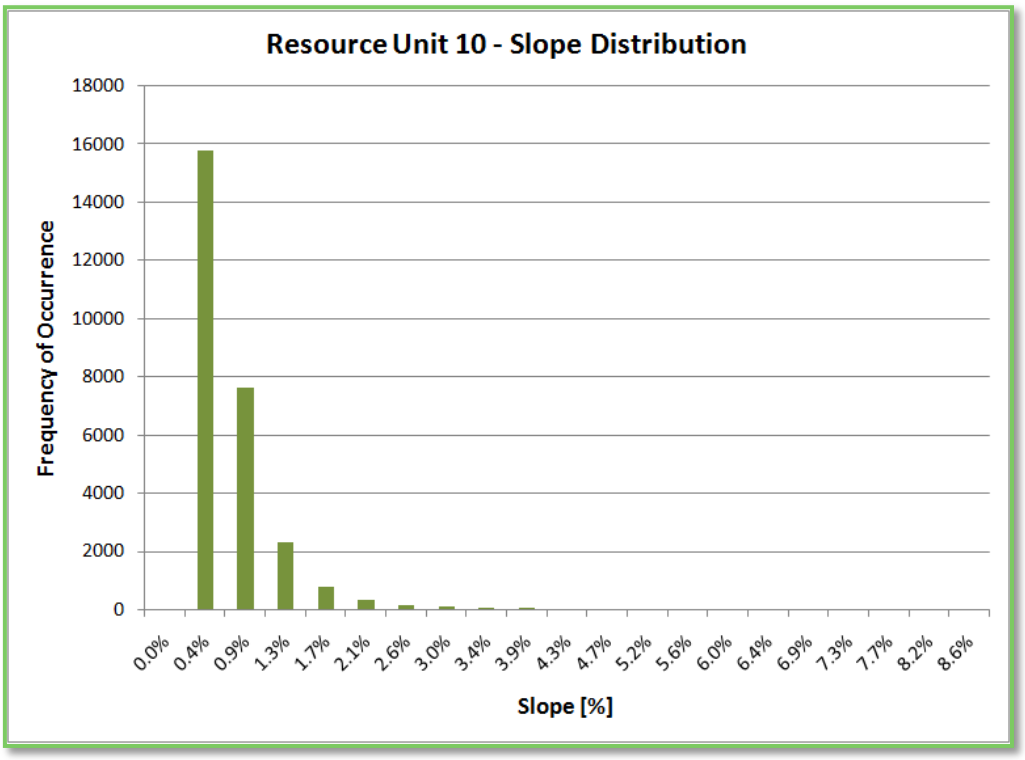


FIGURE D 10: SLOPE HISTOGRAM FOR RU10

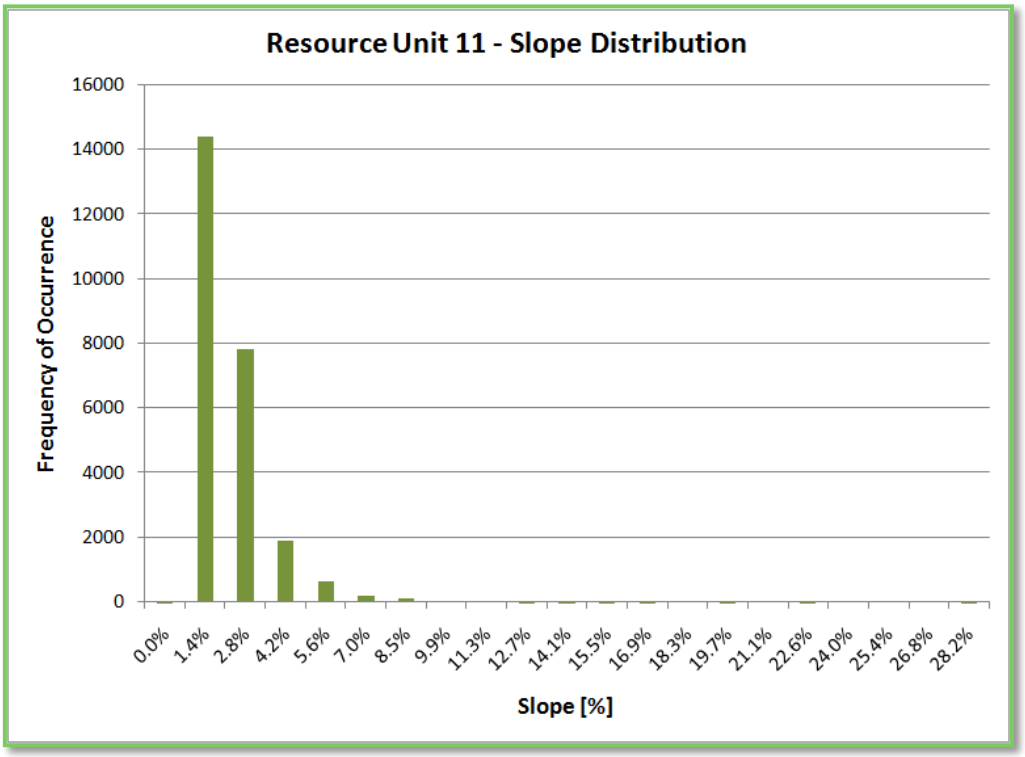


FIGURE D 11: SLOPE HISTOGRAM FOR RU11

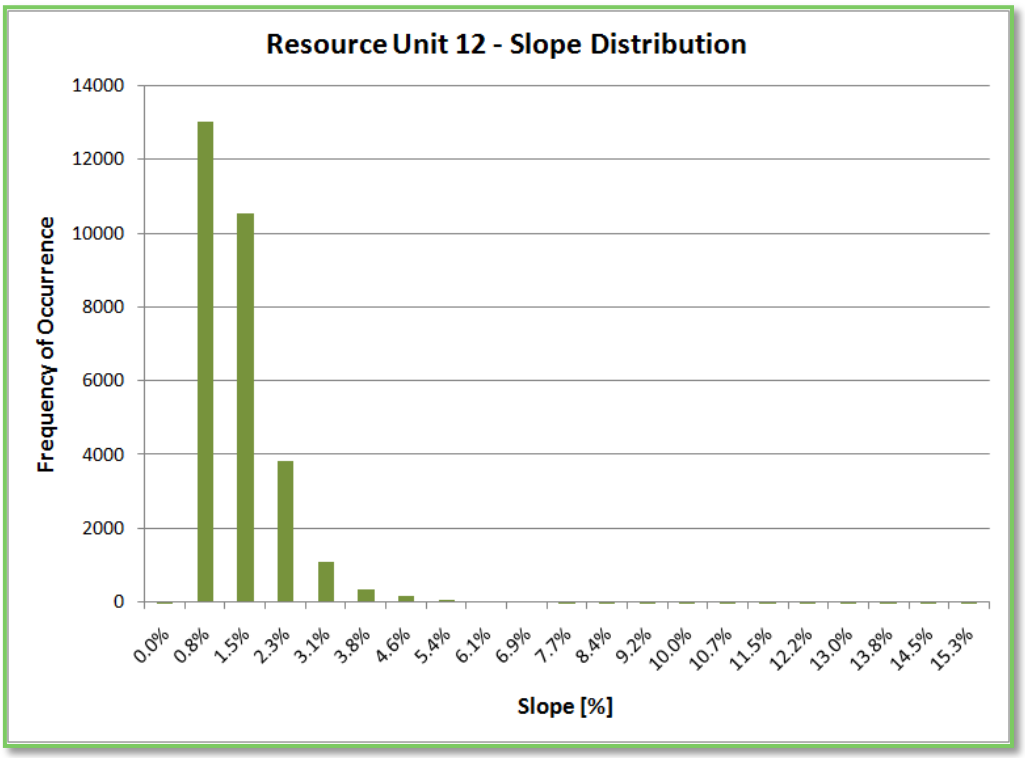


FIGURE D 12: SLOPE HISTOGRAM FOR RU12

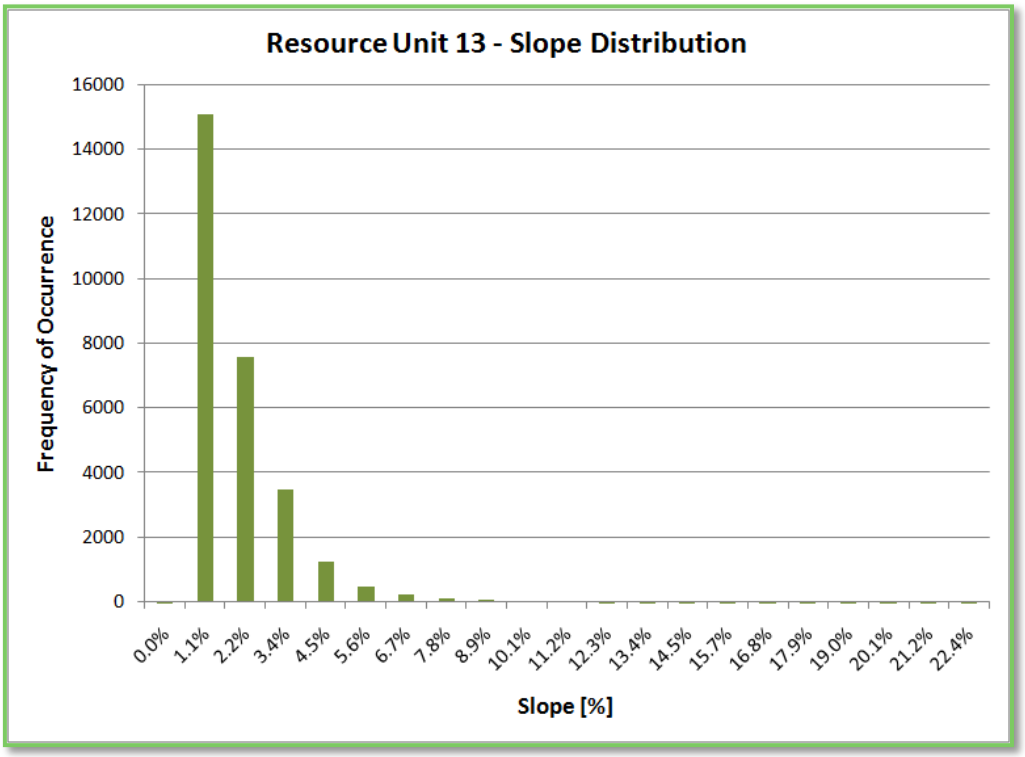


FIGURE D 13: SLOPE HISTOGRAM FOR RU13

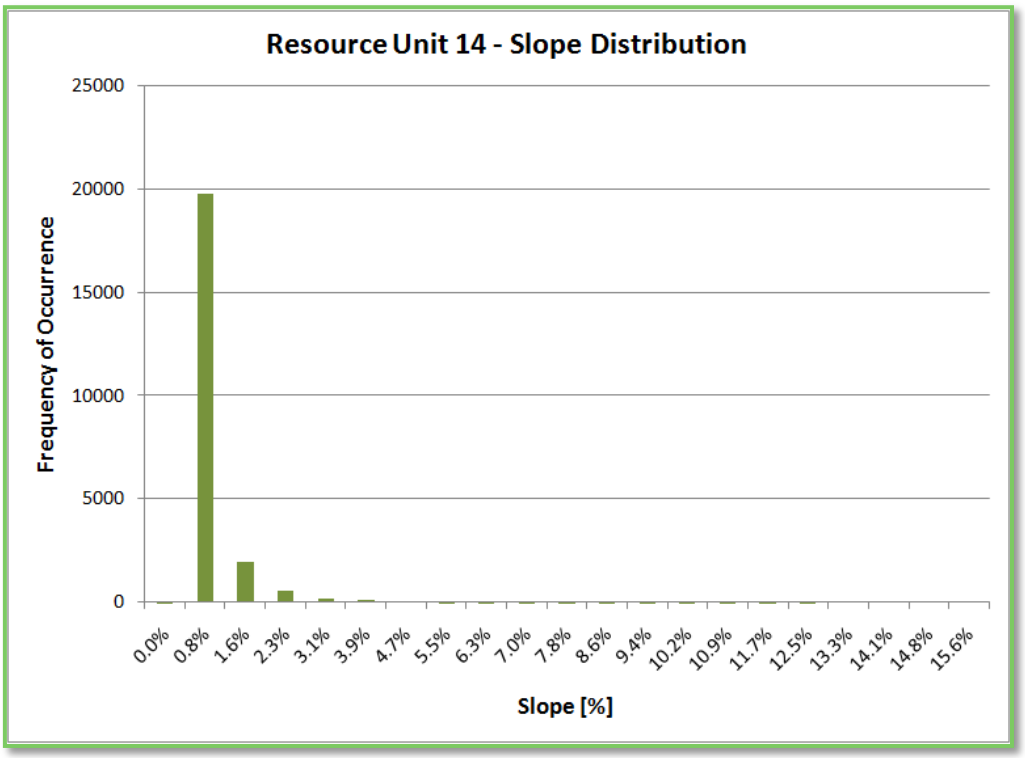


FIGURE D 14: SLOPE HISTOGRAM FOR RU14

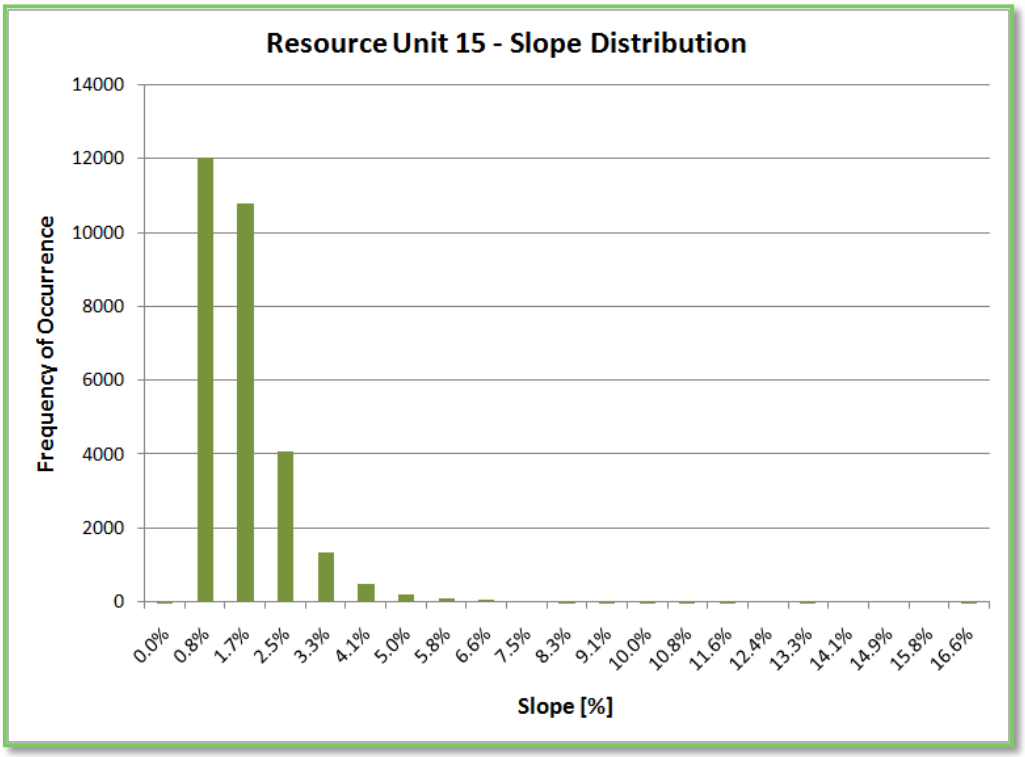


FIGURE D 15: SLOPE HISTOGRAM FOR RU15

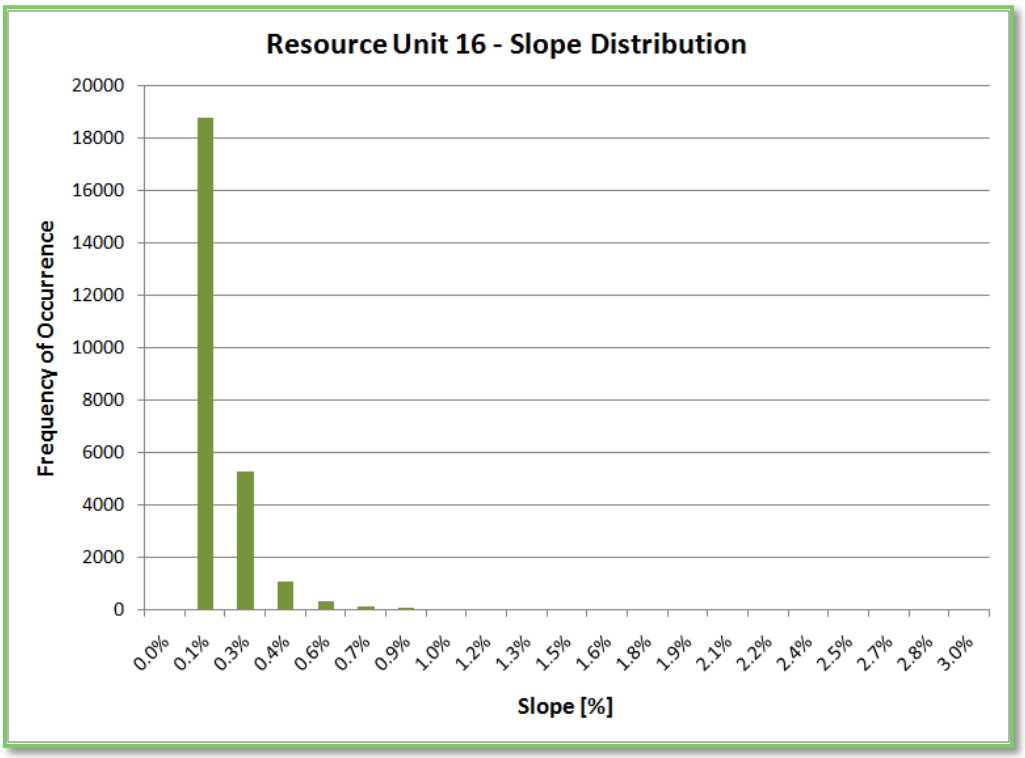


FIGURE D 16: SLOPE HISTOGRAM FOR RU16

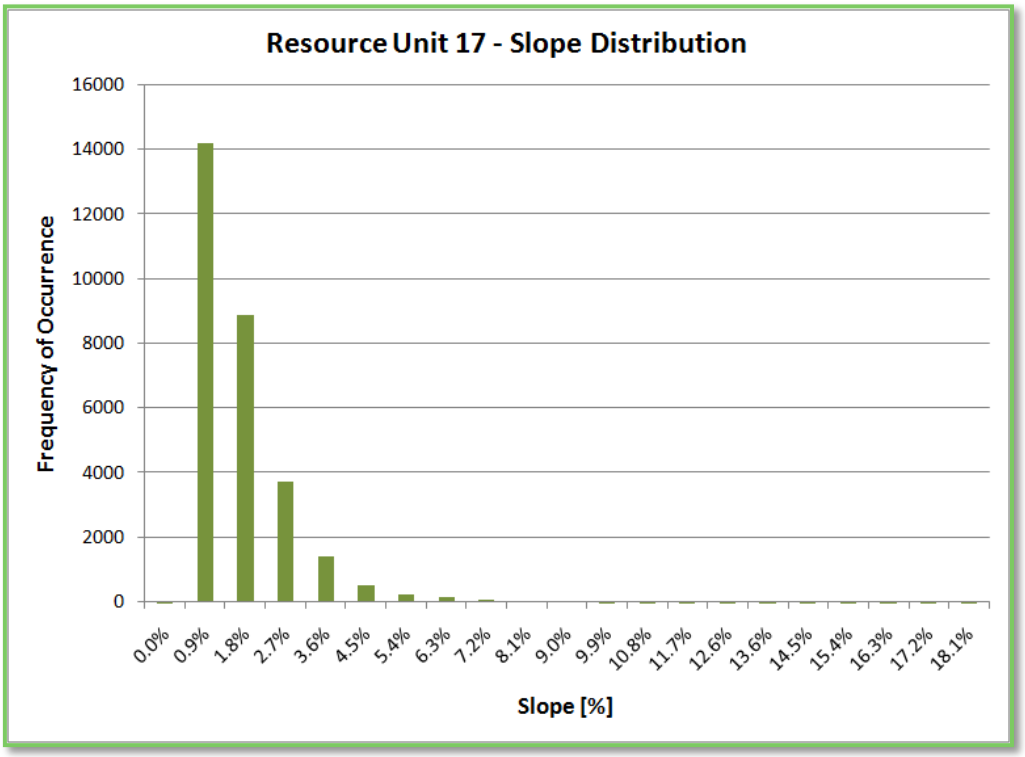


FIGURE D 17: SLOPE HISTOGRAM FOR RU17

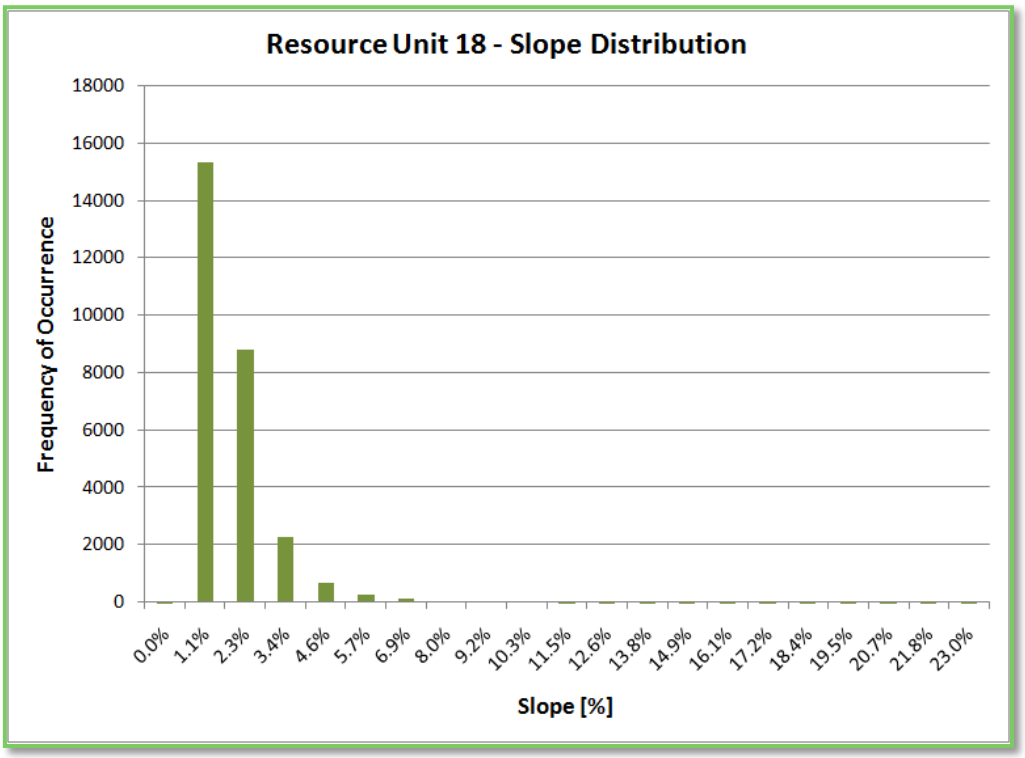


FIGURE D 18: SLOPE HISTOGRAM FOR RU18

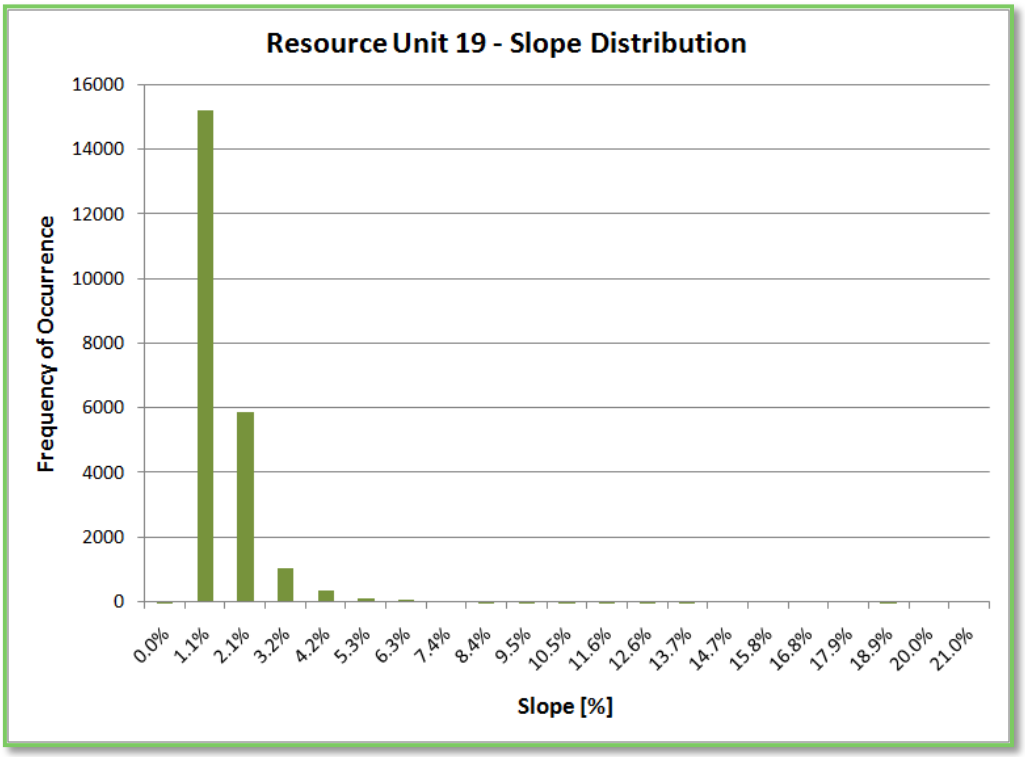


FIGURE D 19: SLOPE HISTOGRAM FOR RU19

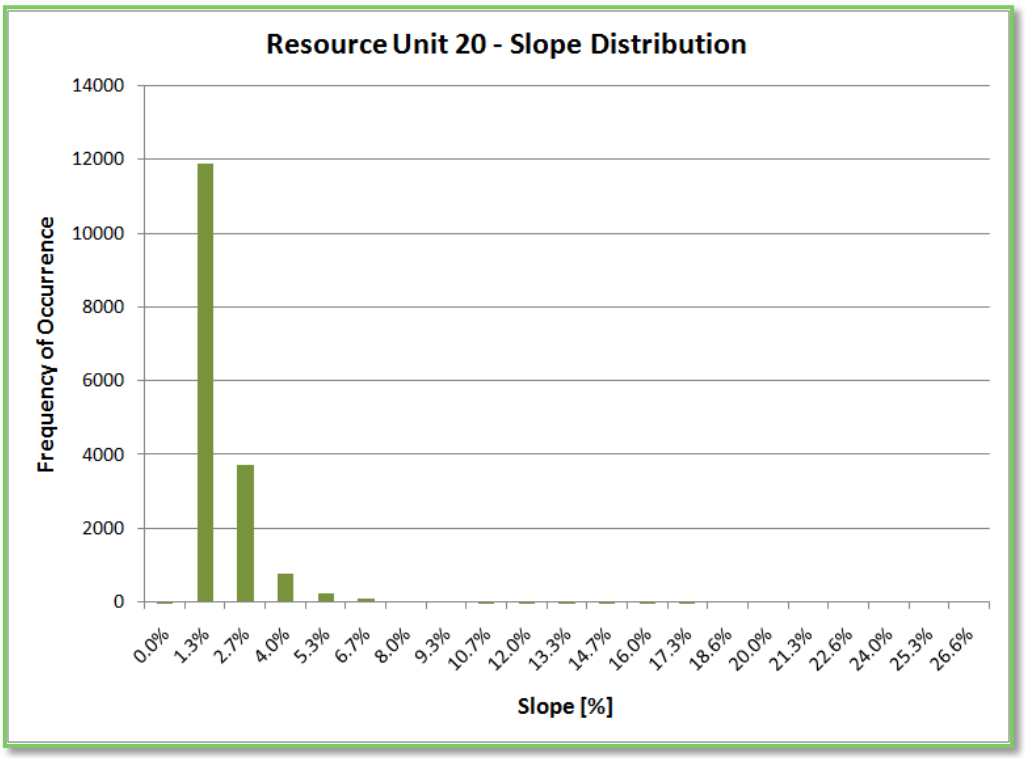


FIGURE D 20: SLOPE HISTOGRAM FOR RU20

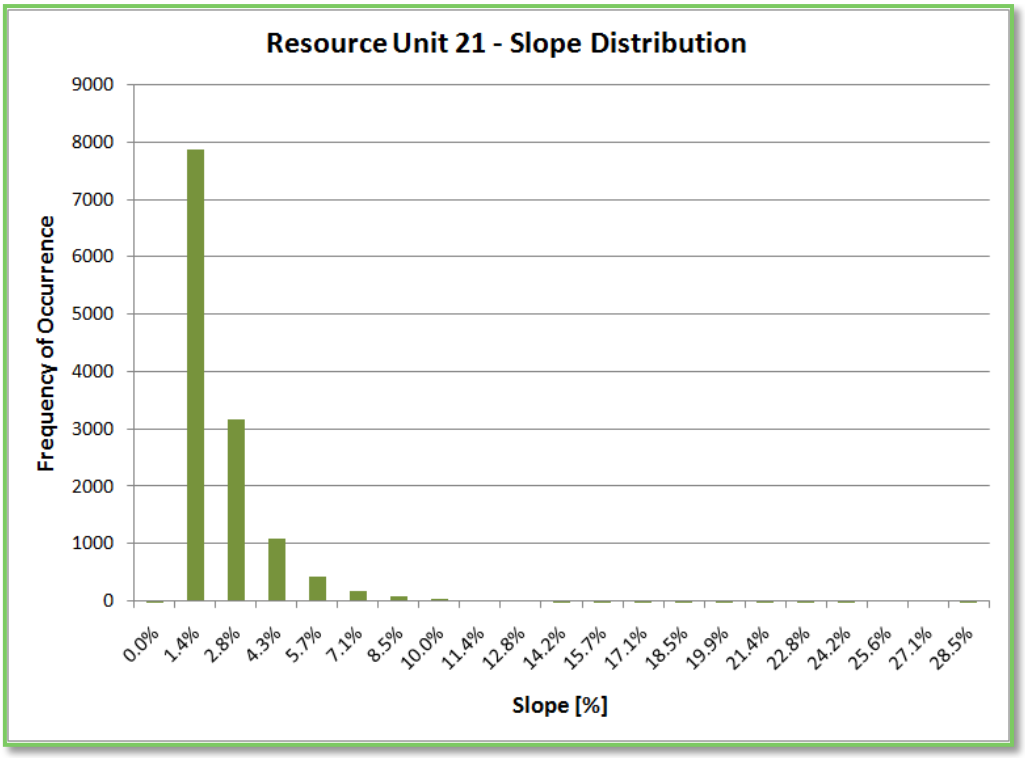


FIGURE D 21: SLOPE HISTOGRAM FOR RU21

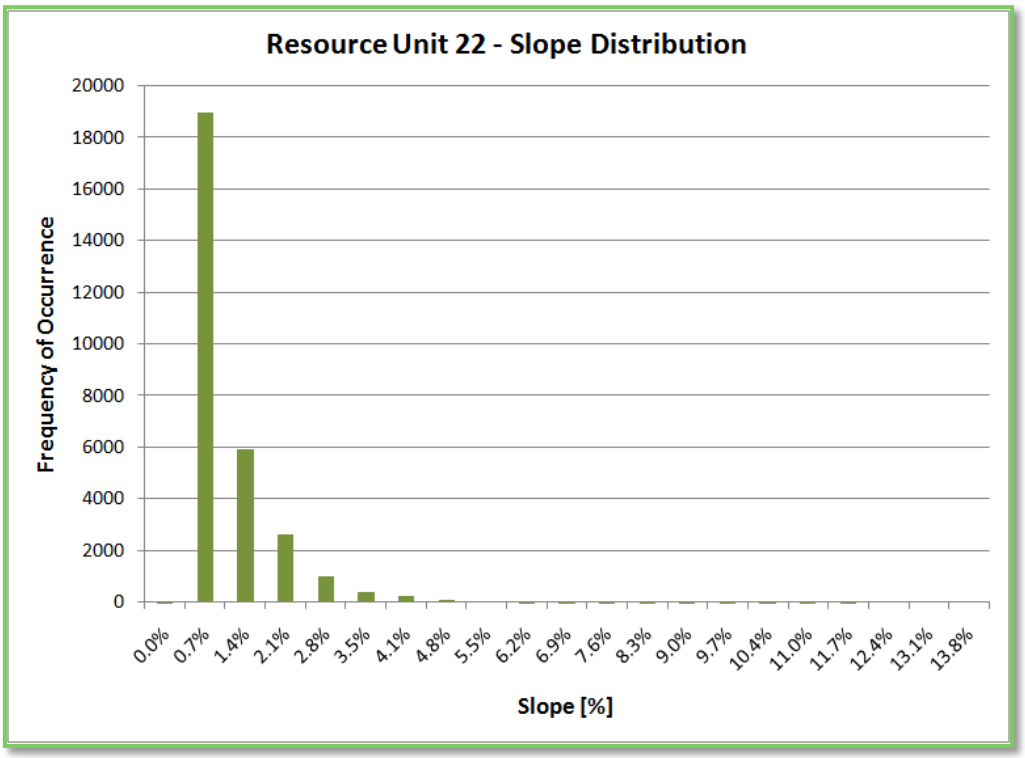


FIGURE D 22: SLOPE HISTOGRAM FOR RU22

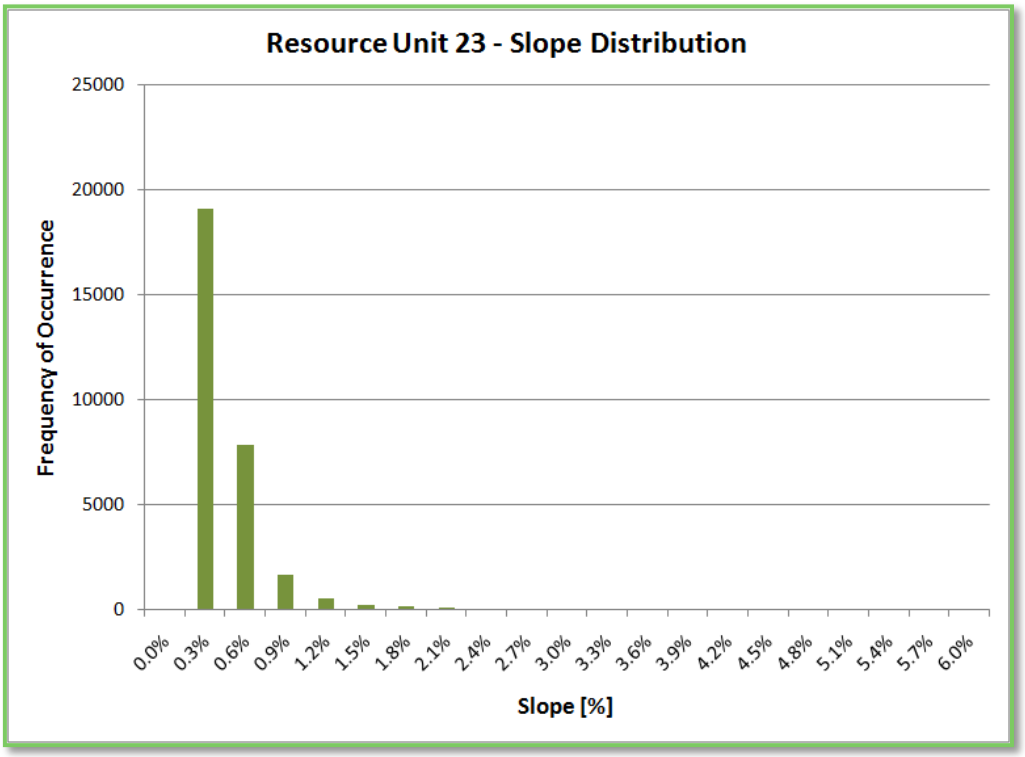


FIGURE D 23: SLOPE HISTOGRAM FOR RU23

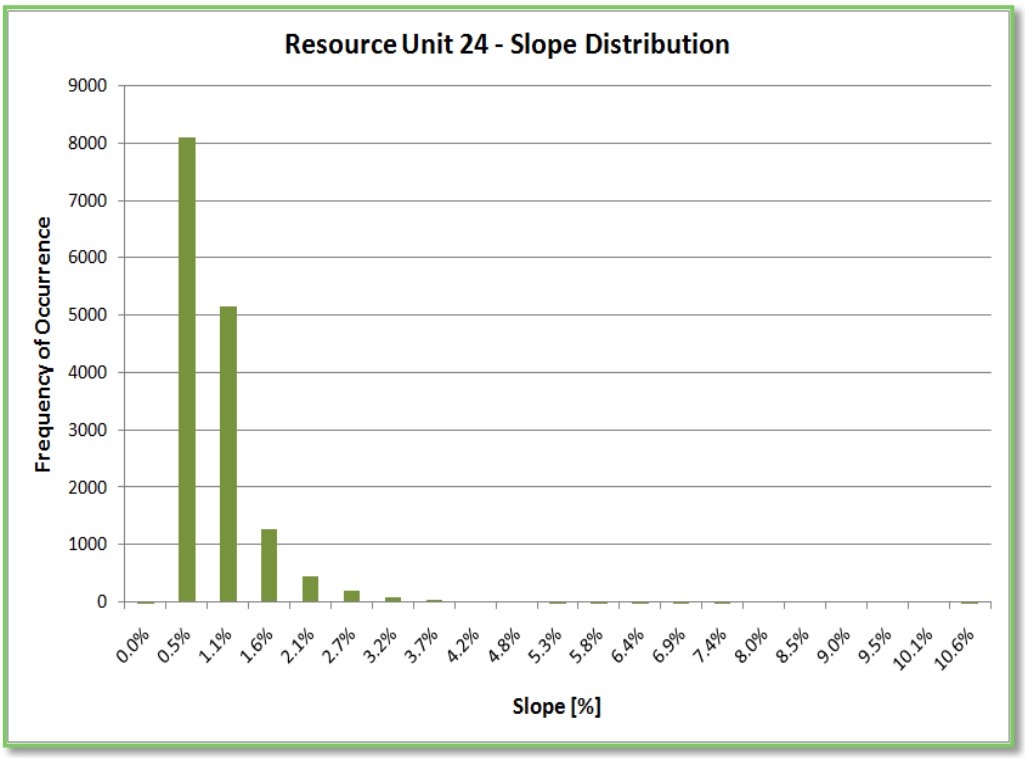


FIGURE D 24: SLOPE HISTOGRAM FOR RU24

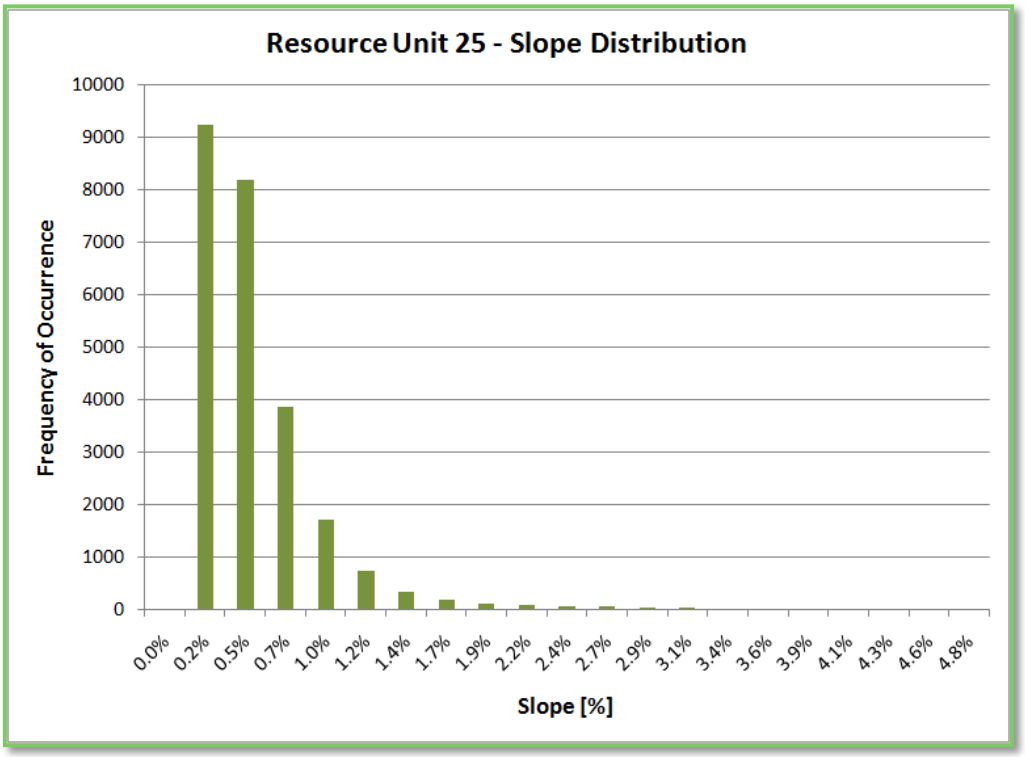


FIGURE D 25: SLOPE HISTOGRAM FOR RU25

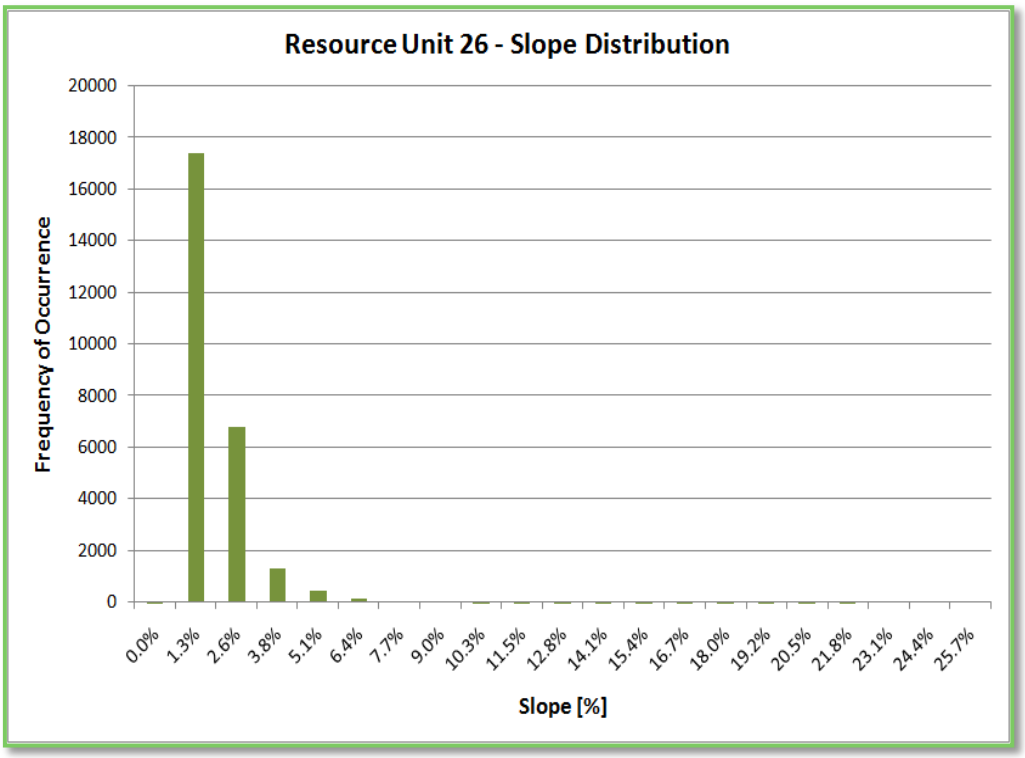


FIGURE D 26: SLOPE HISTOGRAM FOR RU26

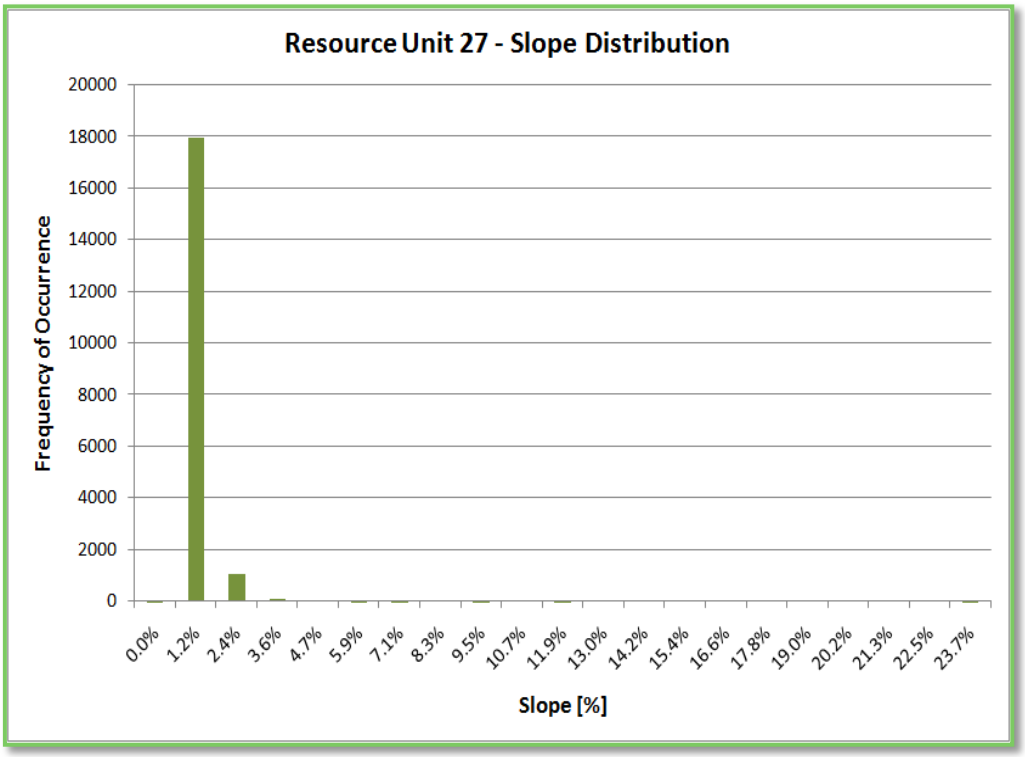


FIGURE D 27: SLOPE HISTOGRAM FOR RU27

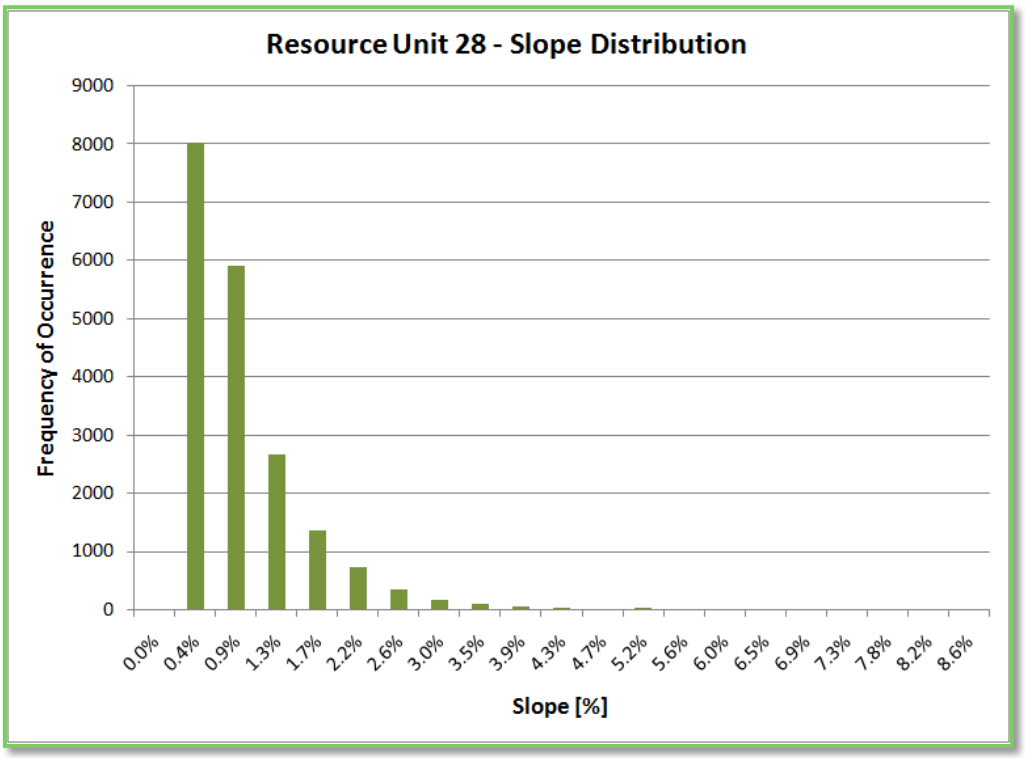


FIGURE D 28: SLOPE HISTOGRAM FOR RU28

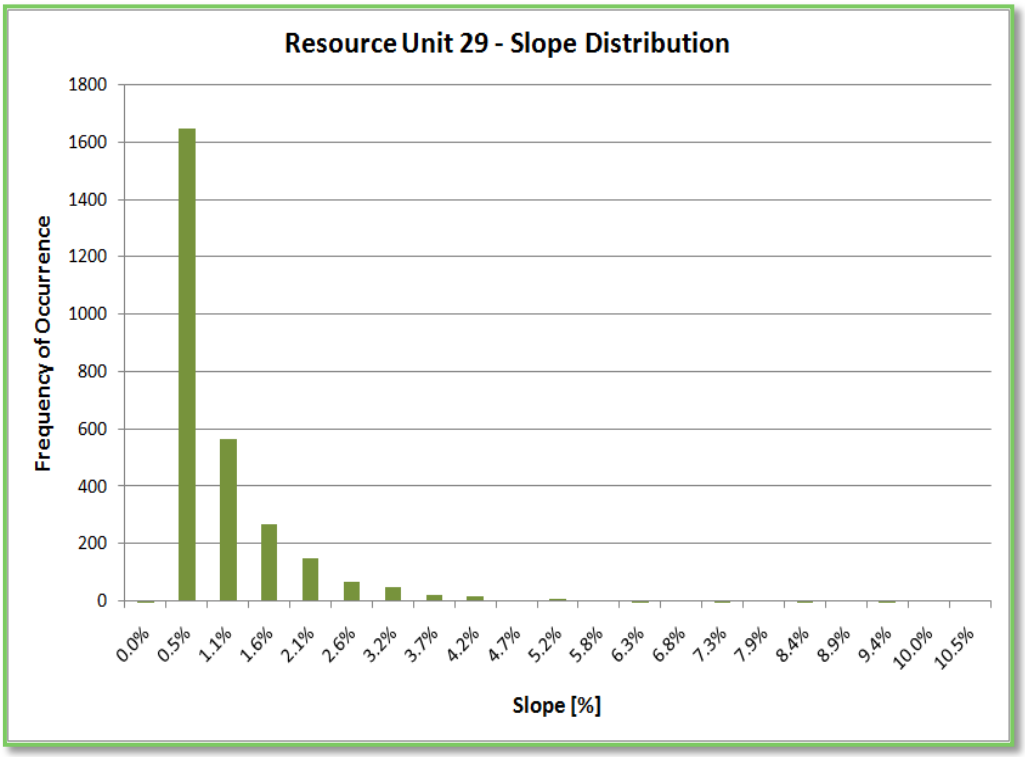


FIGURE D 29: SLOPE HISTOGRAM FOR RU29

CAPACITY BUILDING

CAPACITY BUILDING

Introduction

The capacity building on this Reserve Determination included the following activities:

- GRDM training course
- Training of post-graduate students
- One field trip

Each of these will be discussed in more detail in the following Sections.

GRDM Training Course

A GRDM training course held in Bloemfontein on 17 & 18 April 2008. The attendance list is documented in **Table 1**.

TABLE 1: LIST OF DELEGATES

Name	Company	Email address	Cell	Telephone
Rupert Sebire	Geomeasure Group	rupert@geomeasuregroup.co.za		0317681103
Elzet Gouws	Geomeasure Group	elzet@geomeasuregroup.co.za		0317681103
Christiaan Vermaak	NSVT	christiaan@nsvt.co.za	0827035680	0514461914
Sampie Shabangu	KOMATI Basin Water Authority	sampie.shabangu@kobwa.co.za		0137810319
Cedric Nelson	NSVT	ccdric@nsvt.co.za		0514461912
Yasmin Rajkumar	DWAF	rajkumY.dwaf.gov.za	0828834125	0313362748
Caiphus Ngubo	DWAF	nguboc@dwaf.gov.za	0828805484	0313362863
Gawie van Dyk	DWAF	vandyk@dwaf.gov.za	0828092408	0538308814

The course was presented by Roger Parsons and Rainier Dennis. All delegates received training on the GRDM process and the associated software. An afternoon was spent on the WMA and more specifically baseflow values.

Training of post-graduate students

All honours and MSc students at the Institute for Groundwater Studies received training on the GRDM software using information from the WMA. The role of three students on the project are highlighted in **Table 2**.

TABLE 2: TRAINING OF STUDENTS

	*OBAKENG MBOTHO* He is currently an honours student at the IGS. DWAF is sponsoring his studies. Once he has finished he will be joining DWAF's learning academy. He was assigned a Groundwater Reserve Determination as an honours project. The focus of the project is the coalfields in the WMA area.

	***MARK SCHAPERS*** Mark is currently an MSc student at the IGS. He is focusing on groundwater use and the impacts thereof in the Zululand aquifer. He will address issues related to the Reserve in his MSc thesis.
	***MICHAEL DU PREEZ*** Michael obtained his PhD at the IGS last year. He was responsible for all the field work in the study area.

Field trip (16 – 17 October 2008)

A field trip was arranged for DWAF officials. The aim of the field trip was to familiarize DWAF officials with the site and the issues related to the Groundwater Reserve within the WMA. The two day field trip was attended by:

- Nancy Motebe (DWAF)
- Yongxin Xu (UWC) – Prof Xu is the external reviewer of the Reserve
- Ingrid Dennis (IGS)
- Rainier Dennis (IGS)
- Amukelani Shibambo (DWAF)
- Puleng Moche (DWAF)
- Ndivhwo Netshiendeulu (DWAF)
- Tichatong Gouah (DWAF)

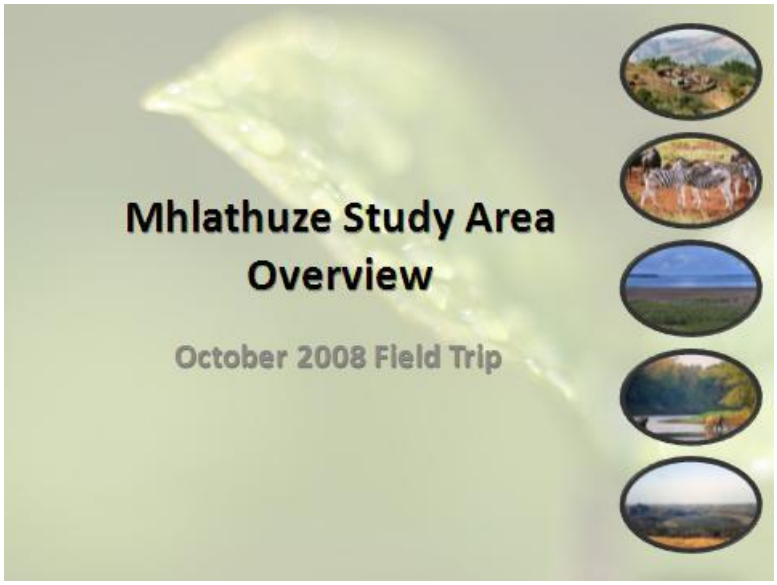
Photo1: In the field with locals collecting their basic water supply

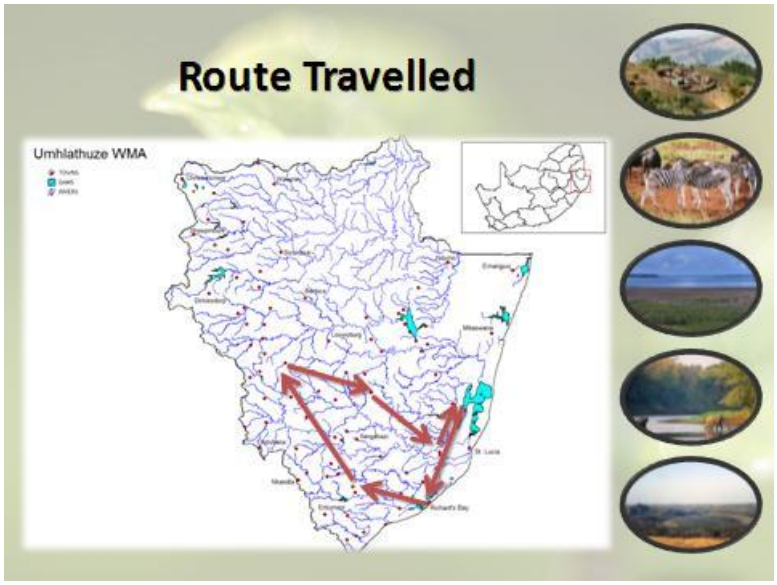
Photo2: In the field with N Motebe and Y Xu deep in discussion

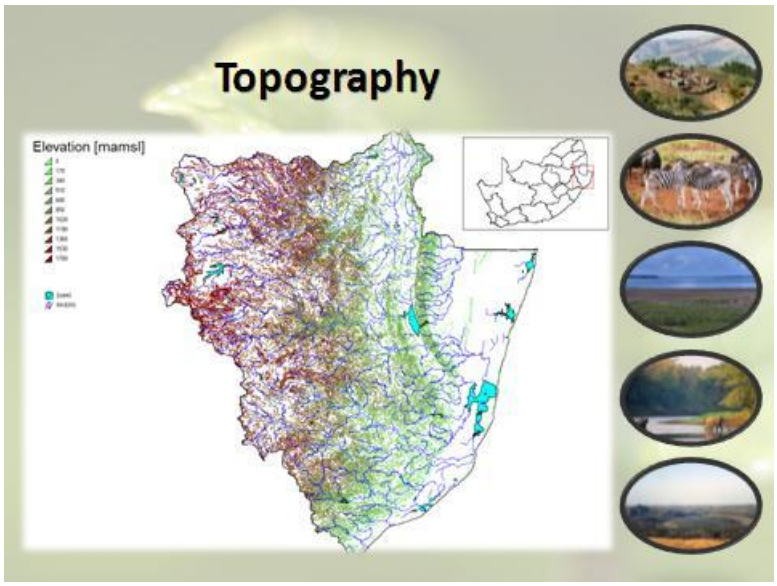
Photo 3: Discussions continue at Eco-lodge

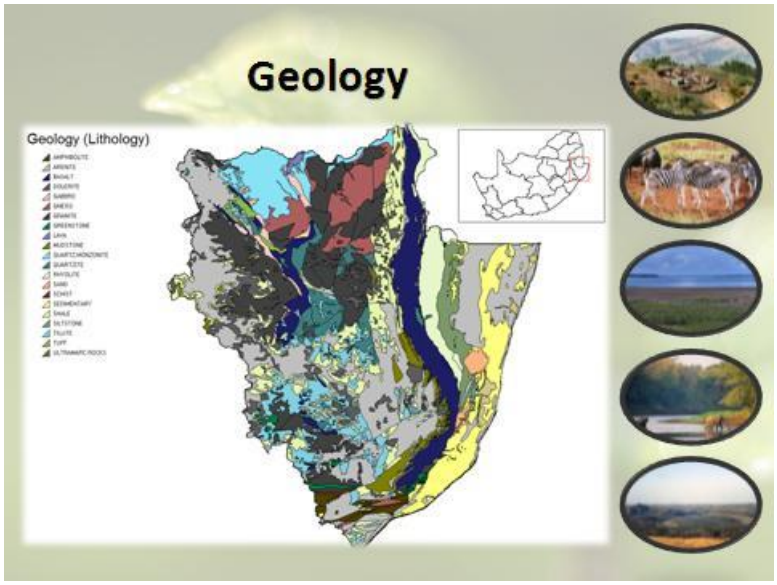
Photo 4: Field trip ends in Richards Bay

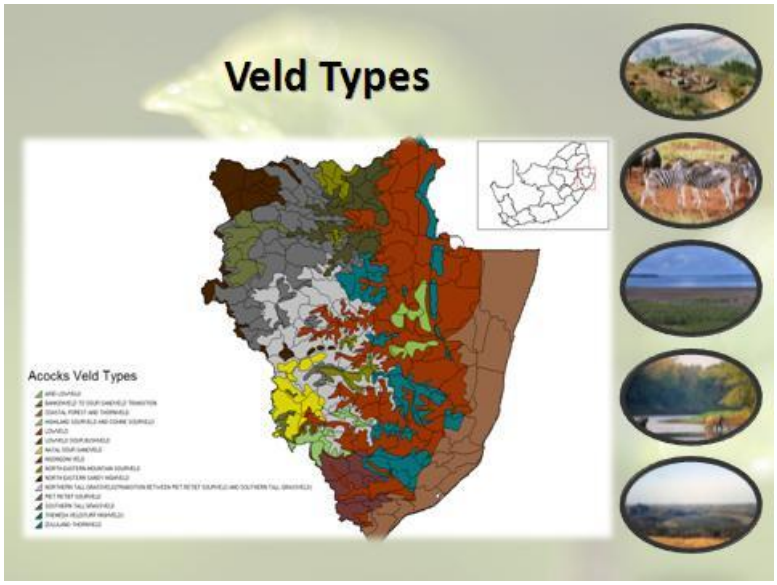
An overview of the field trip is shown in the slides below:

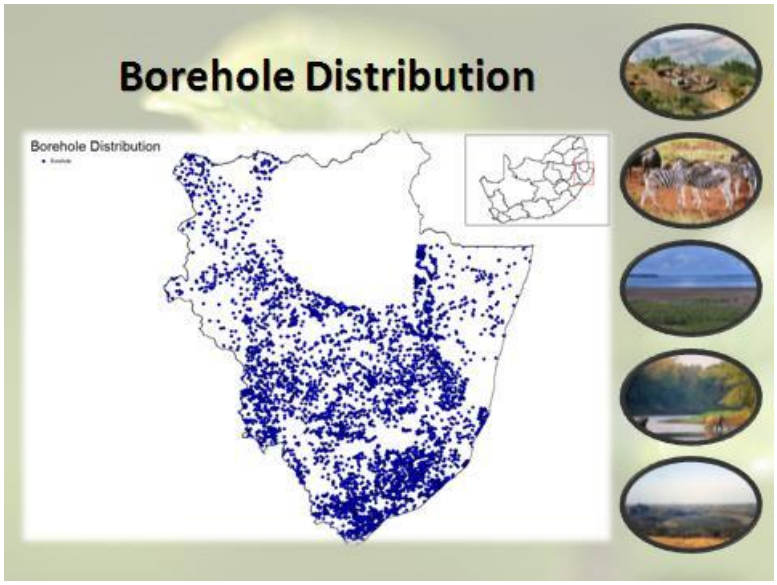







Geology
Geology (Lithology)


Veld Types
Acocks Veld Types


Borehole Distribution
Borehole Distribution

Plantations Groundwater Use

- Pine and Eucalyptus (25 l/d)
- Blue Gum (50 l/d)
- Area under plantation = 18 000 km^2
- Conservative use estimation based on 60% Blue = 11 500 Mm^3/a

Examples of Common Quality Factors at Rural Villages

- Positions of pit latrines
  - Microbial
  - Nitrate
- Animals mostly Cattle and Goats
- Informal waste sites

Examples of Common Quality Factors at Towns

- Waste Sites
- Cemeteries
- Sewage Works
- Petrol Stations
- Small Industry

Small Localised Impact

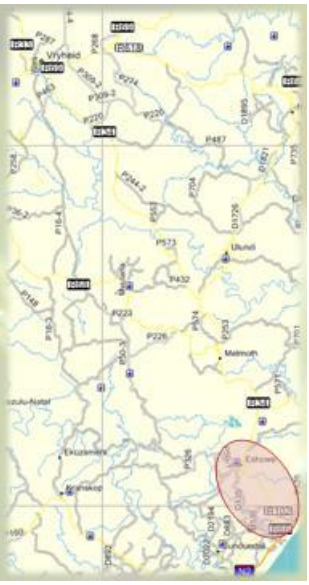
Examples of Town Specific Quality Stress Factors

- Richards Bay
  - Paper Mill
  - Coal Stock for Export
  - Fuel Depot
  - Mining (BHP Billiton, RBM)
  - etc
- Vryheid
  - Feedlots
  - Coal Mines

Hot Spots

R66 to Estowe

- Sugar Cane
- Small Plantations
- Scattered villages
  - Jojo's for collecting rain water
  - Boreholes / Wells
  - Surface Water ?

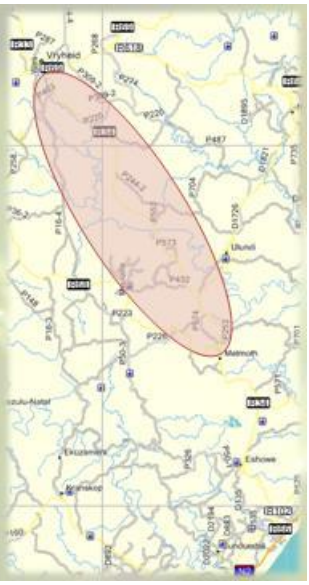


Eshowe to Melmoth

- Orchards (irrigation from river)
- Medium sized plantations
- Scattered villages
  - Jojo's for collecting rain water
  - Boreholes / Wells

Melmoth to Vryheid

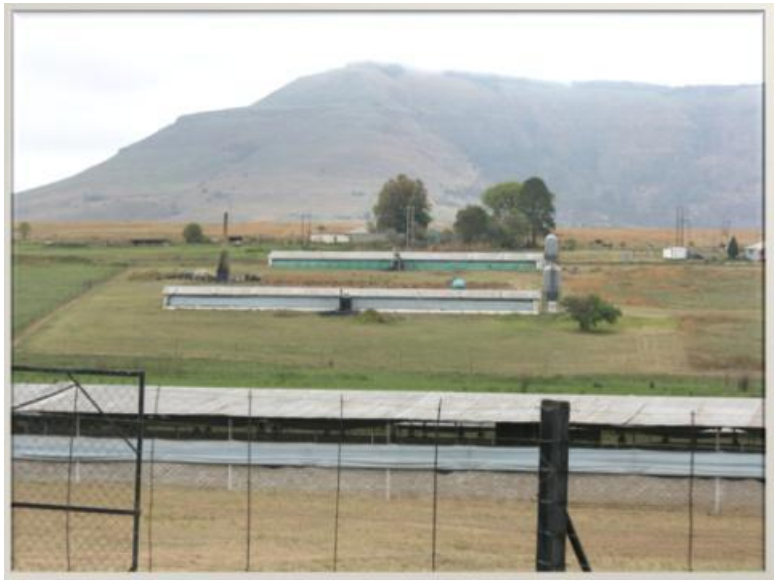
- Very arid landscape
- Lots of erosion visible
- Scattered villages
  - Boreholes / Wells
  - Surface Water?




WHITE UMFOLOZI
RIVER
1979

Vryheid to Nongoma

- Medium sized plantations
- Cattle and chicken farming (feedlots)
- Collieries
- Erosion
- Scattered villages
  - Boreholes

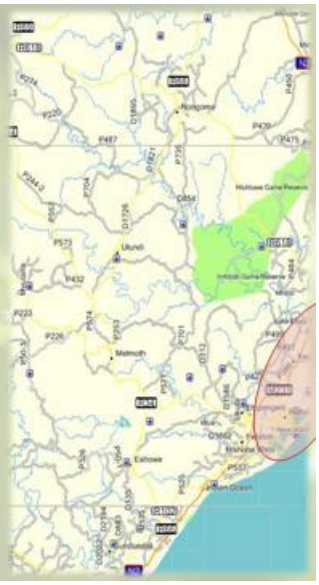


Nongoma to Hluhluwe Game Reserve

- Water use same as Nongoma situation

N2 to Richards Bay

- Sugar Cane
- Plantations
- Richards Bay Indusrty
- Drought Relieve Coastal Flats




mondi

Concerns

- Water tankers delivering water
- 6 Year drought (drought relieve programme)
- Perennial rivers dry
- Sea water intrusion
- Mining
- Industry
- Forestry
- Trans-boundary Aquifer Systems