BEST PRACTICE GUIDELINE G1

STORMWATER MANAGEMENT

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Structure of BPG G1

- Chapter 1 – Introduction to guideline
- Chapter 2 - The principles and objectives to be incorporated in the storm water management plan.
- Chapter 3 - The hydrological processes that need to be considered in a storm water management plan.
- Chapter 4 - Practical steps and considerations - a step-by-step process for setting up the SWMP.

Objectives of BPG G1

- To provide a practical procedure to develop a SWMP.
- To define the contents of a management system that will ensure compliance with the targets and objectives of the SWMP.
- To define where the expertise of suitably qualified persons is required at the various stages of plan development, implementation, operation and review/audit.
- To reference relevant legislative and policy issues that need to be considered in a SWMP.

Effects of poor SW management

- Downstream contamination of natural watercourses due to runoff or spillage of contaminated storm water.
- Flooding, with the resultant damage to property, land and potentially loss of life.
- Loss of catchment yield and addition of large volumes of water to the mine water balance when optimal runoff of clean storm water is not achieved.
- Erosion of beds and banks of waterways.
- Increased recharge through spoils or fracture zones, unnecessarily increasing the water volume that comes into contact with contaminants.

General Principles

- Clean water to be kept clean and routed to natural water course
- Dirty water to be collected and contained in separate system with minimum spillage or seepage risk
- SWMP must be sustainable over mine life cycle and different hydrological cycles
- All statutory requirements and stakeholders must be considered and incorporated

PRINCIPLE 1: KEEP CLEAN WATER CLEAN

- Identify and where possible, maximise areas of the mine that will result in clean storm water runoff and ensure that runoff from these areas is routed directly to natural watercourses and not contained or contaminated
- Ensure that clean storm water is only contained if the volume of the runoff poses a risk. This contained clean water should then be released into natural watercourses under controlled conditions.

PRINCIPLE 2: COLLECT AND CONTAIN DIRTY WATER

- Ensure the minimisation of contaminated areas, reuse of dirty water wherever possible and planning to ensure that clean areas are not lost to the catchment unnecessarily.
- Ensure that seepage losses from storage facilities (such as polluted dams) are minimised and overflows are prevented.
- Ensure that all possible sources of dirty water have been identified and that appropriate collection and containment systems have been implemented and that these do not result in further unnecessary water quality deterioration.

PRINCIPLE 2: COLLECT AND CONTAIN DIRTY WATER – cont.

- Ensure that the contained dirty water is managed according to the hierarchy of mine water management steps
- Ensure that less polluted water or moderately polluted water is not further polluted. Where possible less and more polluted water should be separated. This will assist in the reuse water strategy and improve possibilities for reuse based on different water quality requirements by different mine water uses. This will also reduce quantities of water eventually requiring treatment.

PRINCIPLE 3: SUSTAINABILITY OVER MINE LIFE CYCLE

- Ensure a commitment from management and staff, including making available adequate human resources (with appropriate qualifications and experience) and adequate financial resources for both the design and implementation of the SWMP.
- Ensure that the SWMP is formulated concurrently with the mine planning and layout of infrastructure and that it takes account of all life cycle phases of the mine from planning through to post-closure.

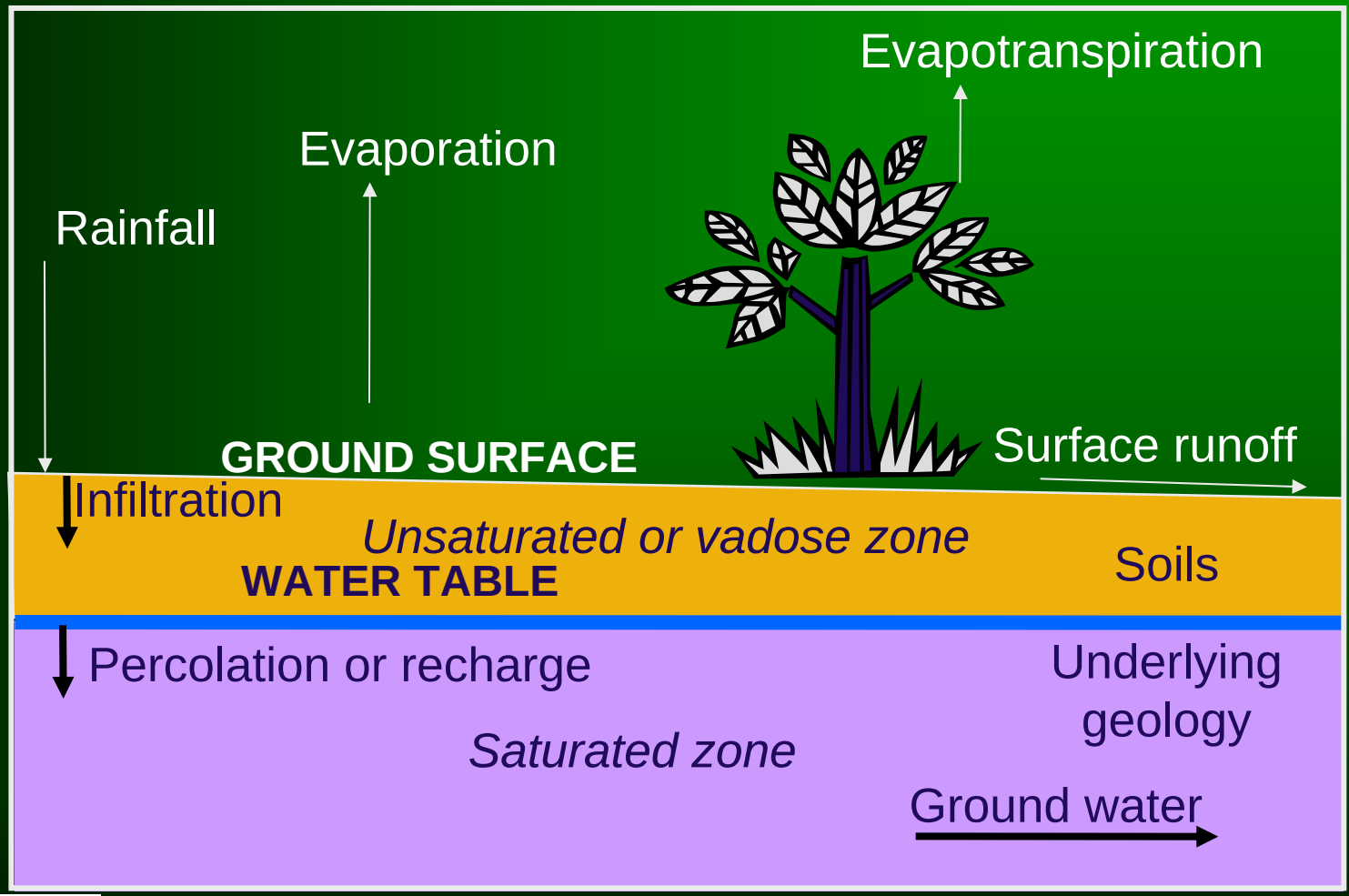
PRINCIPLE 3: SUSTAINABILITY OVER MINE LIFE CYCLE – cont.

- Identify and quantify the risk of failure of components of the SWMP and the consequences of such failure. Risk management is critical to the success of the SWMP, including the consideration of the consequences of extreme events (extreme rainfall and emergency events), as well as potential water shortfalls in areas subject to drought.
- Consider possible changes or upgrades (increased production, additional facilities, expansions etc) that might occur during the life cycle of the mine.

PRINCIPLE 4: CONSIDERATION OF REGULATIONS & STAKEHOLDERS

- Identify items of legislation relevant to the environment and water resources and ensure compliance with these (refer to Chapter 5).
- Include effective liaison with the Department of Water Affairs and Forestry (DWAF) to ensure that the statutory requirements are met.
- Communicate and liaise with Catchment Management Agencies.
- Incorporate the constitutional rights of the environment and other users of the water resource and consider the expectations of interested and affected parties

Hydrological Cycle

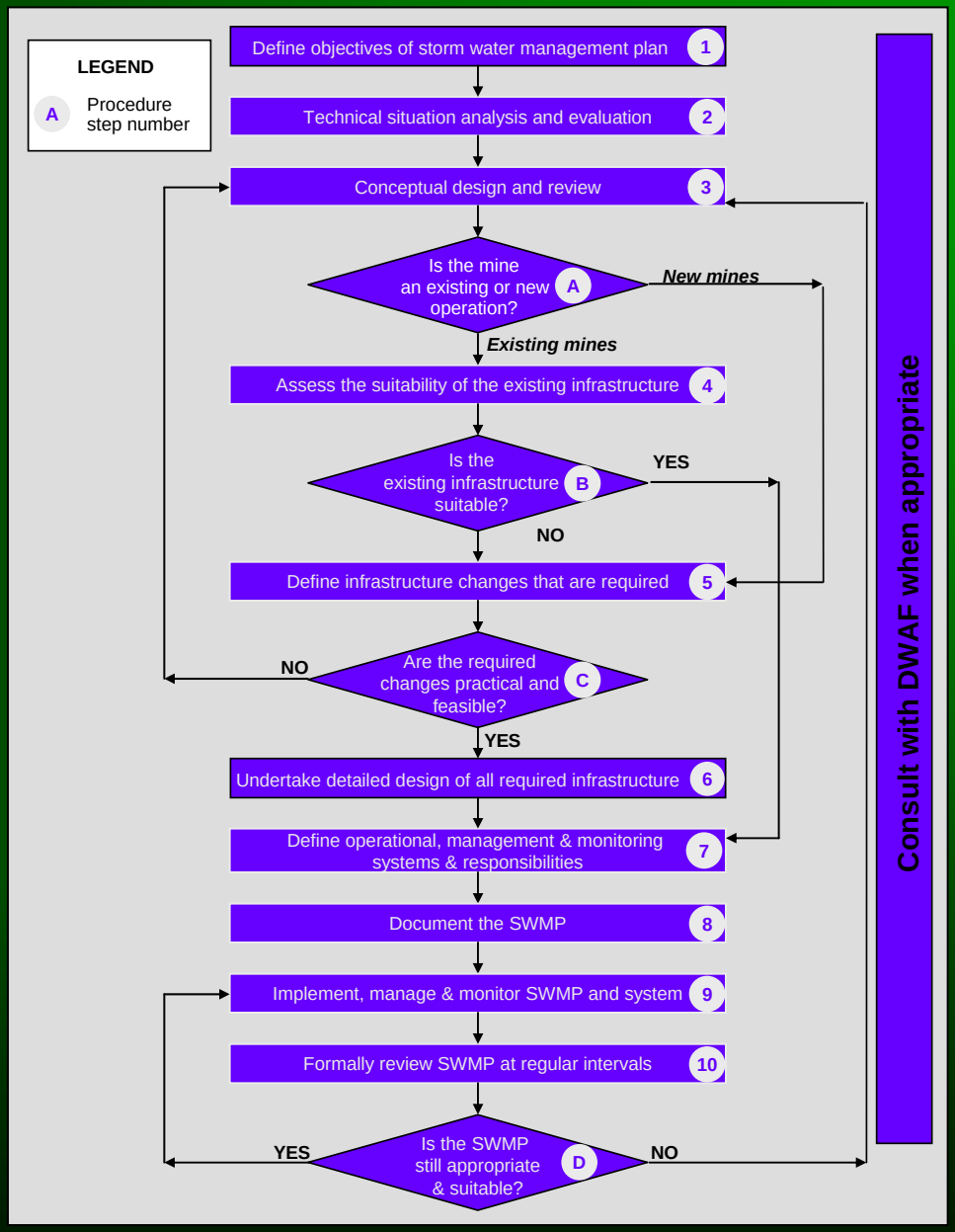


Overview of hydrological cycle

- Precipitation (extreme events & seasonal variations)
- Infiltration (difficult to quantify precisely but generally > 80% of precipitation)
- Surface Run-off (dependant on many variables but generally MAR order of 6-10% of precipitation)
- Evapotranspiration (varies greatly dependant on ground cover)
- Evaporation (varies between 1400 – 2400 mm/year)
- Percolation or recharge (undisturbed = 3-5 % of precip.)
- Stream flow (flow in a definable watercourse)
- Ground water flow (water flow within aquifers)

Practical Steps & Considerations

- Divided on basis of mine life cycle phase
- Exploration phase – impacts normally small
- Design & Construction Phase:
  - Formulating SWMP is planning process to examine all options to prevent/minimise pollution
  - Must incorporate performance checks to ensure objectives are met
  - SWMP must be robust and be updated



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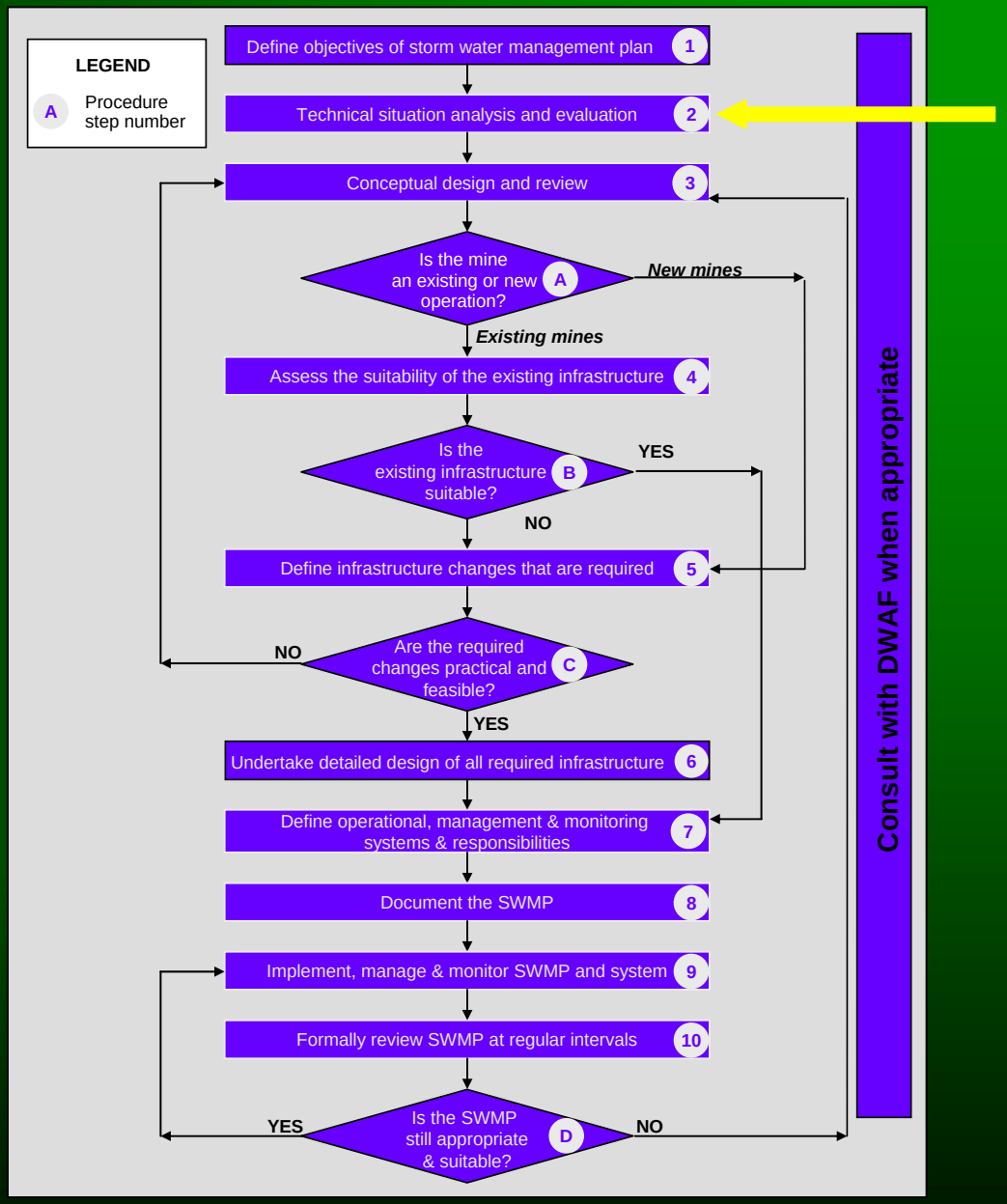
Step 1: Define SWMP Objectives

- Objectives must be specific, measurable, attainable and feasible
- Typical objectives could relate to:
  - Catchment objectives to be met
  - Statutory requirements
  - Management of risk for defined recurrence
  - Water balance management
  - Setting of performance indicators
  - Meeting set water quality objectives



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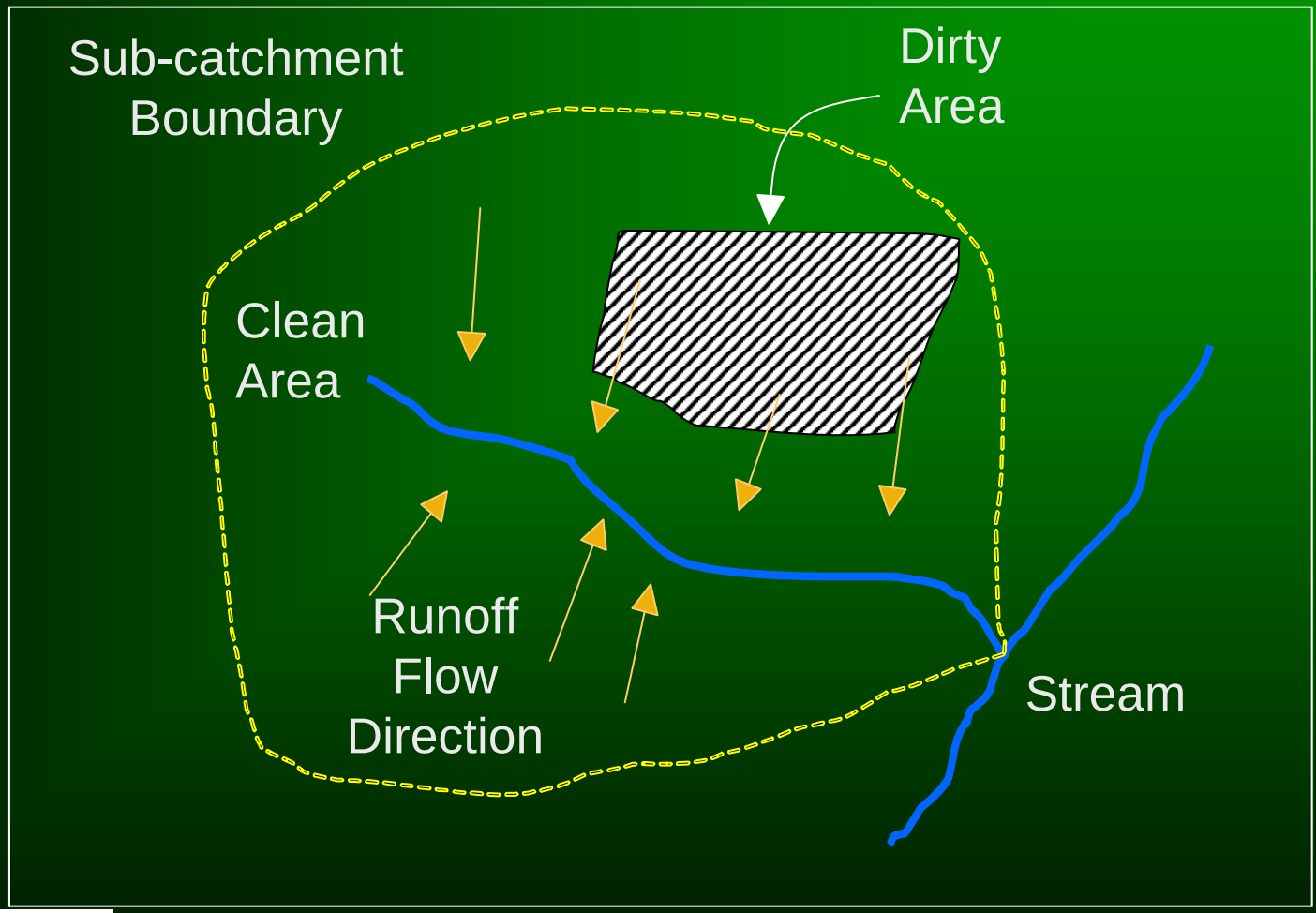
Step 2: Technical Situation Analysis & Evaluation

- Divide mine area into clean and dirty areas
- Identify areas where mining will affect surface hydrology
- Identify physical location & characteristics of existing water management infrastructure

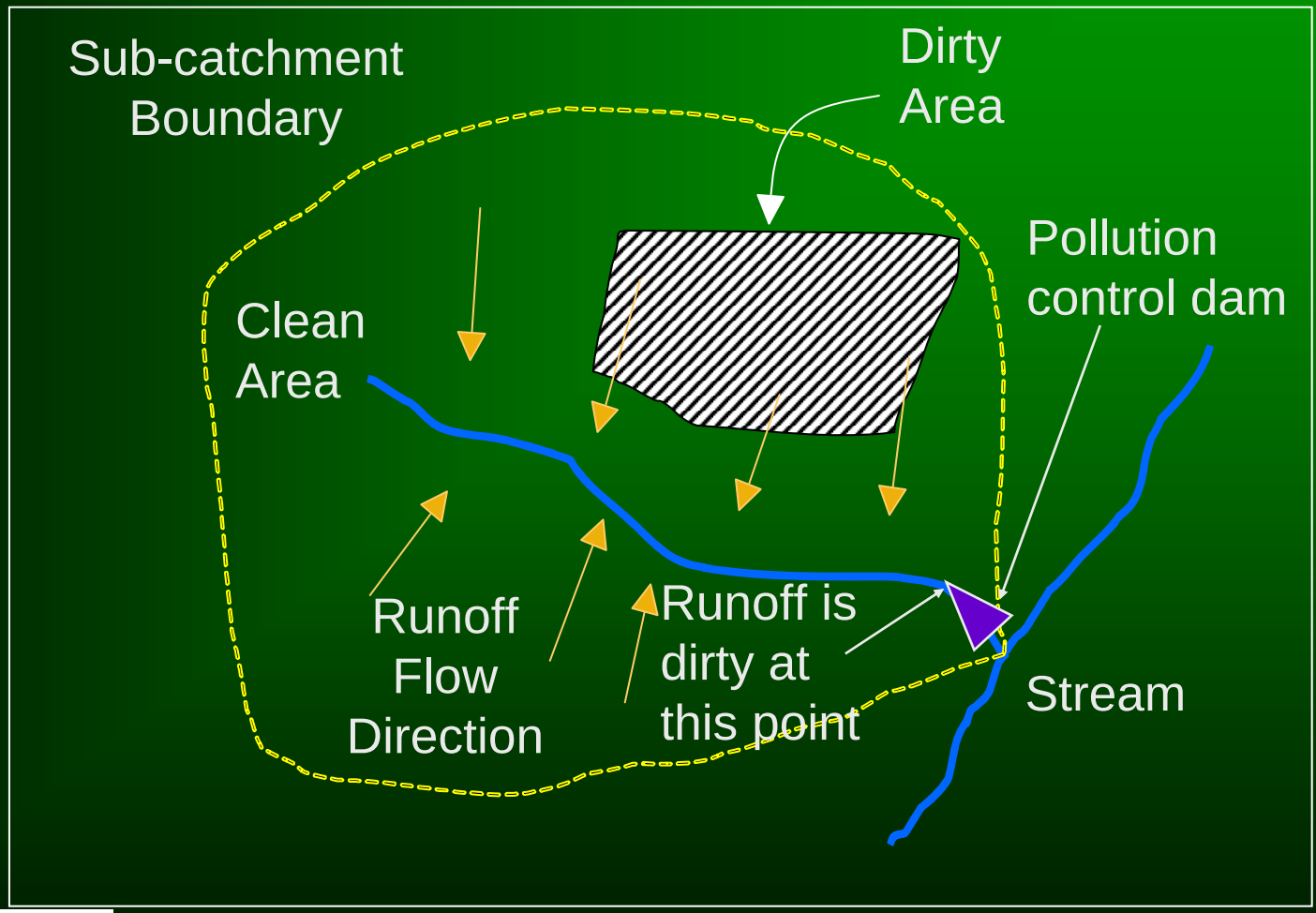
Divide mine into clean & dirty areas

- Preferably done on basis of actual stormwater data
- Alternatively based on planned land use
- May subdivide ‘dirty’ areas into ‘moderately dirty’ and ‘very dirty’ to facilitate water reuse and reclamation
- Clean area examples: residential area, undisturbed ground, well rehabilitated areas, tarred roads, administrative offices
- Moderately dirty area examples: workshops and storage yards (where oil is not handled); poorly rehabilitated areas
- Dirty area examples: beneficiation plants; workshops (where oil is handled); residue disposal facilities, haul roads, opencast pits, pollution control dams

No storm water management



Poor storm water management



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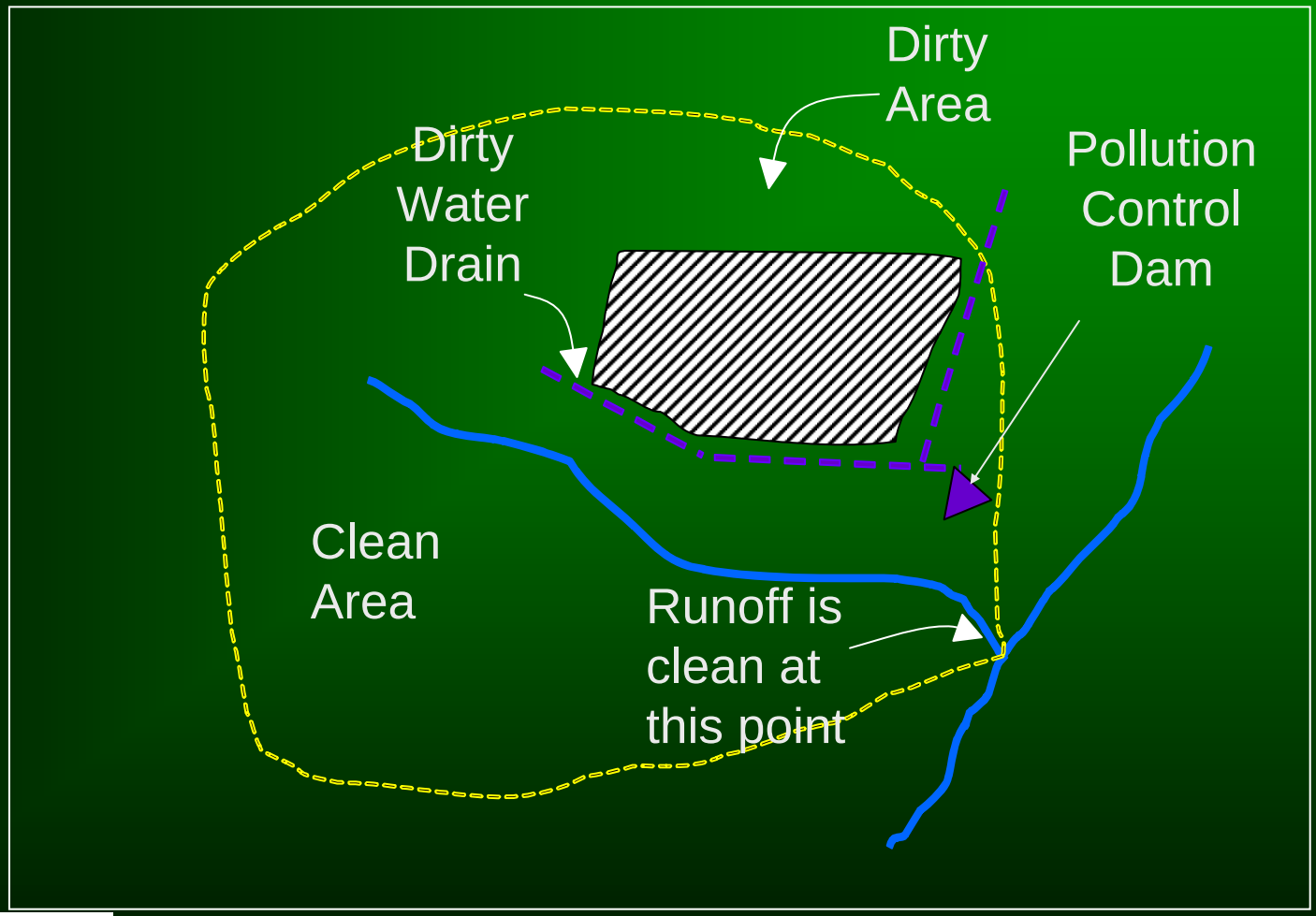
Improved storm water management



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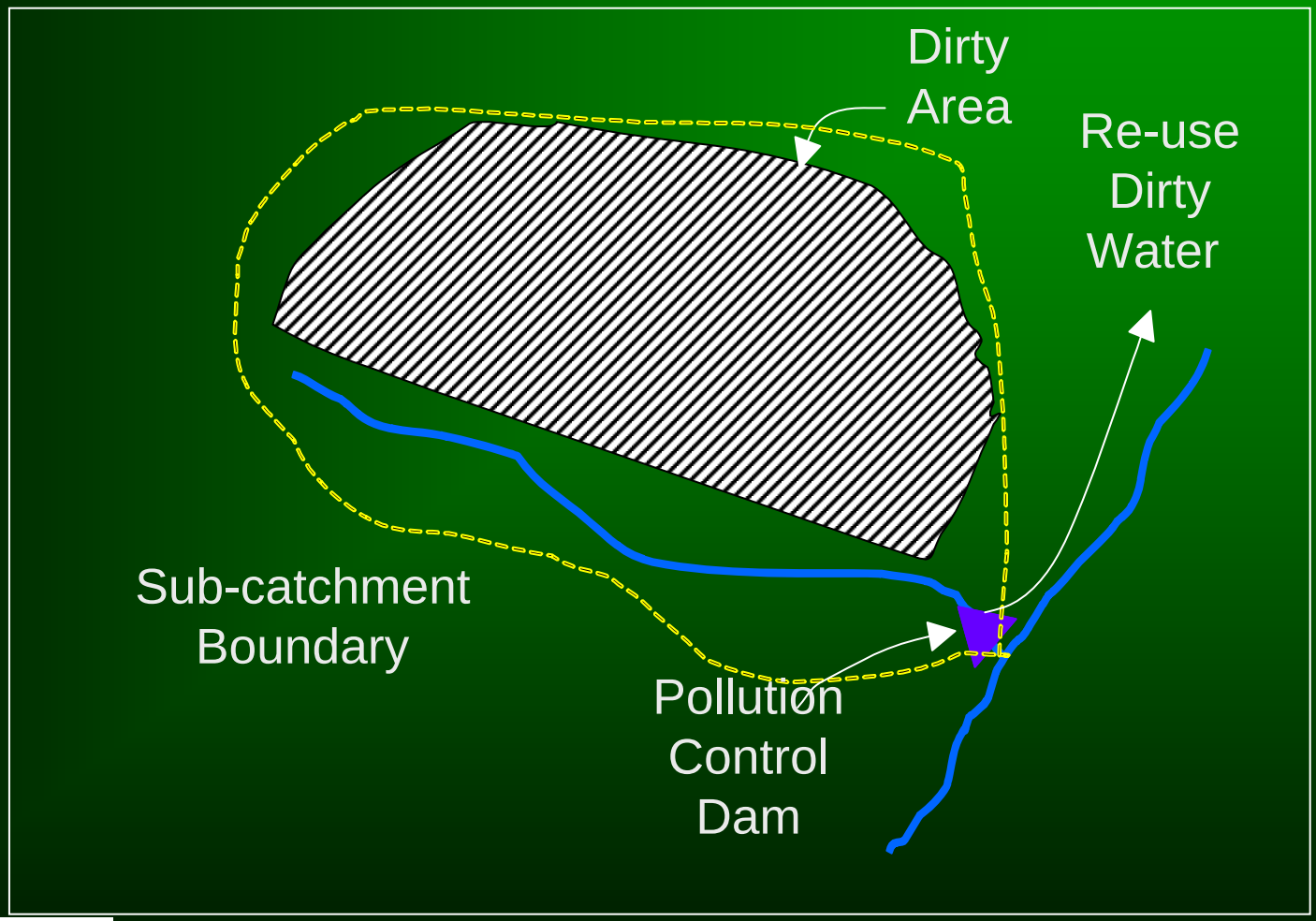
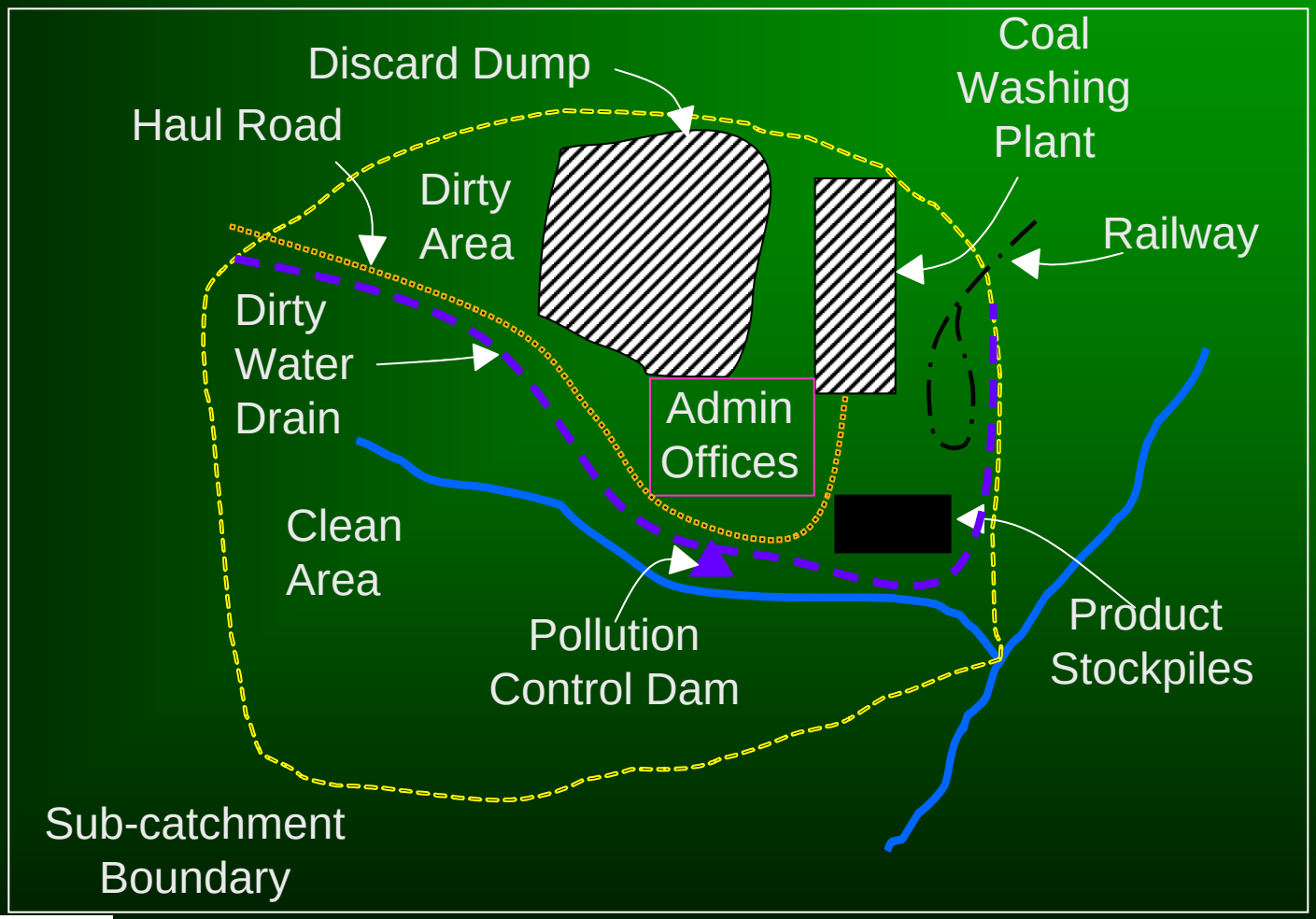
Acceptable storm water management

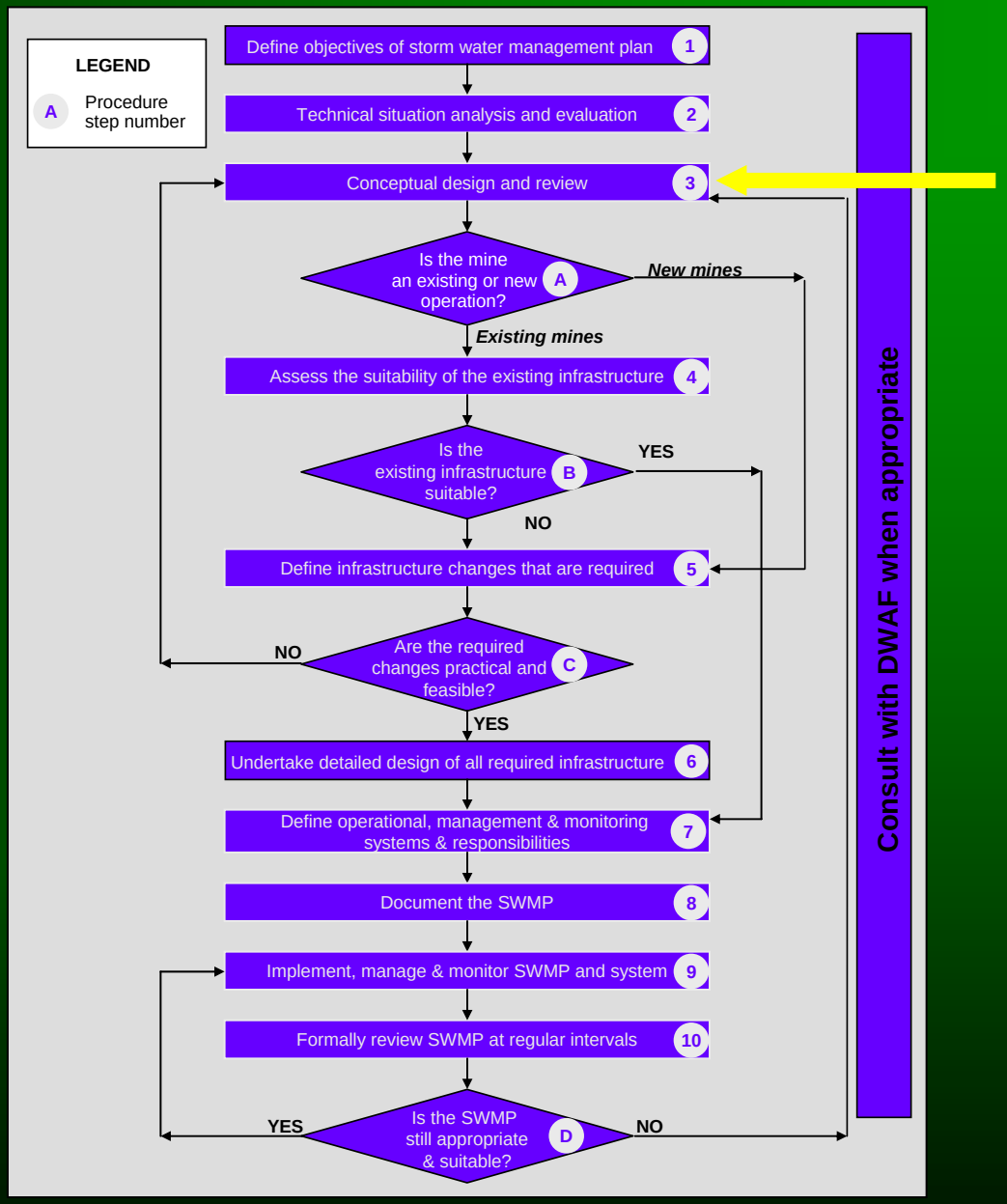


Integrated storm water management



Components of a stormwater management system

- Dams: underlying geology, location, surface area, depth, capacity, freeboard, overflow point, size and capacity of spillway, height of wall, lining, etc
- Pumps: type, rated capacity, number of operational and standby units, on/off control mechanism, etc
- Pipelines: length, diameter, construction material, lining, condition, inlet and outlet elevations, etc
- Storage tanks: location, capacity, construction material, lining, overflow point, level control mechanism, operating strategy etc
- Open channels: start and end point elevations, gradients, construction material, cross-section, erosion protection, condition, estimated maximum flow capacity



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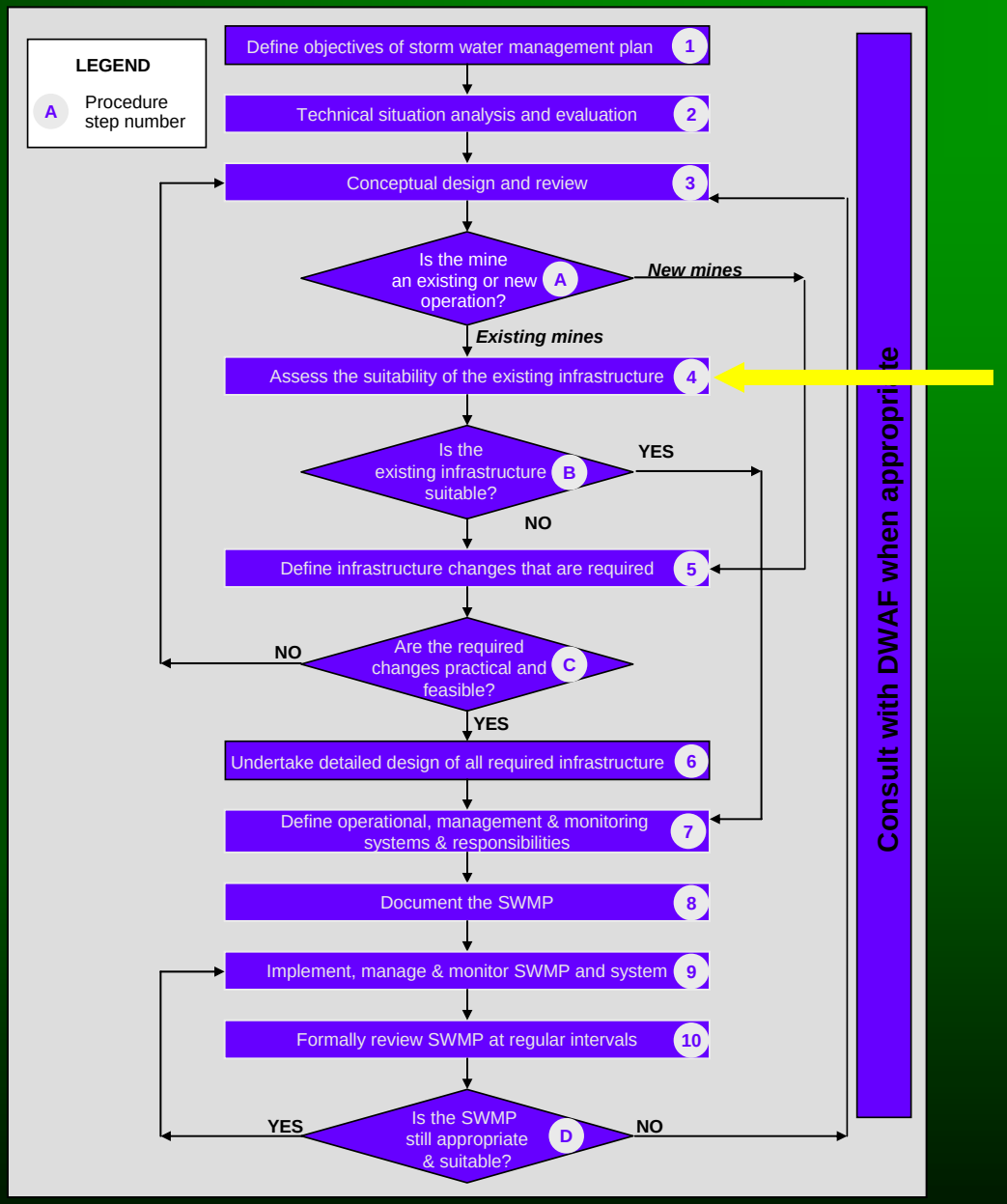
Step 3: Conceptual Design & Review

- Should involve a suitably qualified person
- Preliminary sizing of system components using rules of thumb and approximate calculations
- Review the following:
  - original objectives set in Step 1
  - Implications of conceptual SWMP on water and salt balances
  - Impact of SWMP on water reuse strategy
  - Performance of existing systems
  - Identify potential fatal flaws
  - Address all mine life cycle phases



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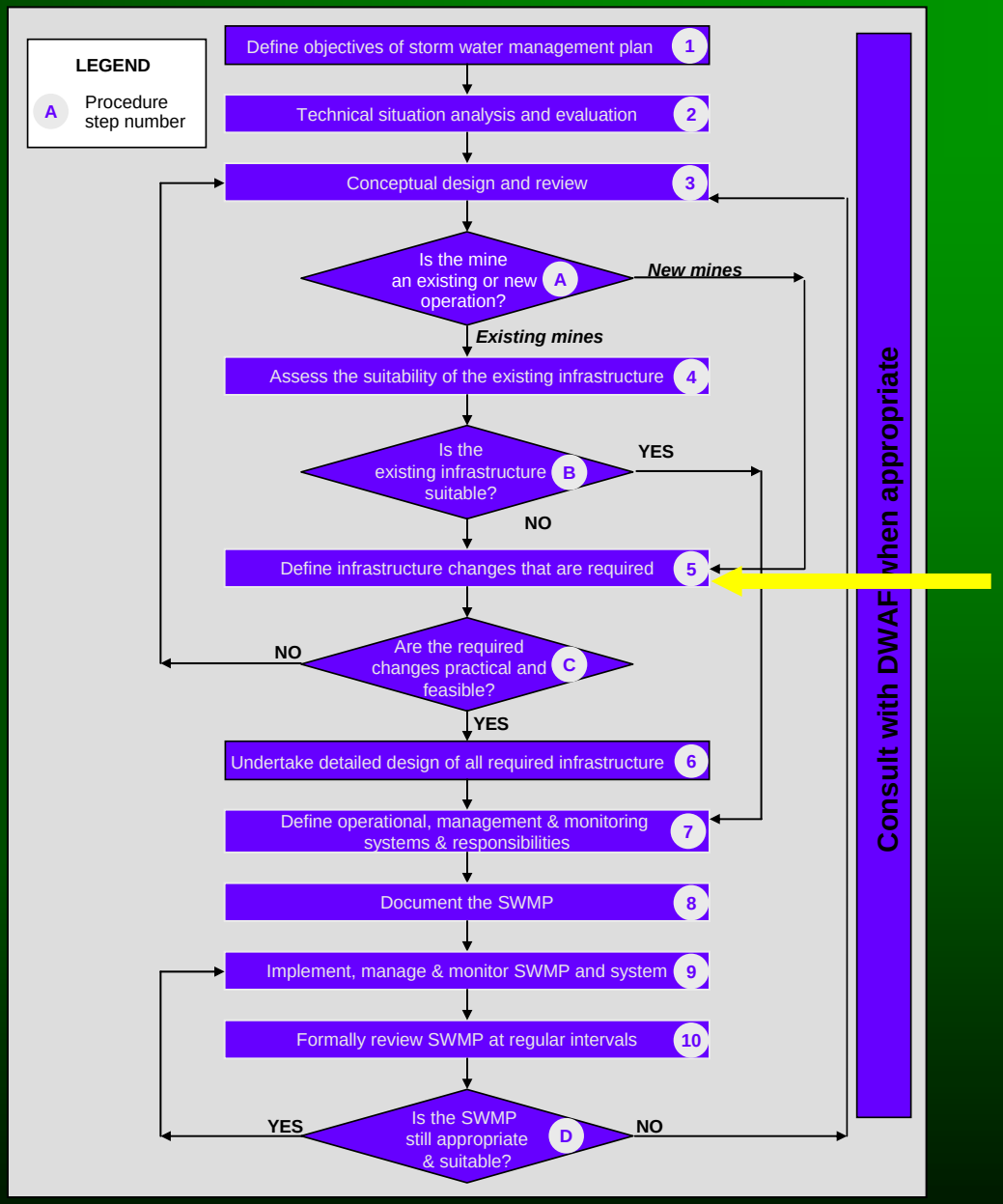
Step 4: Assess suitability of existing infrastructure

- For existing mines, adequacy of existing storm water management systems can be assessed by a suitably qualified person in terms of meeting SWMP principles and objectives.
- Review must include physical infrastructure and staffing, training and monitoring systems



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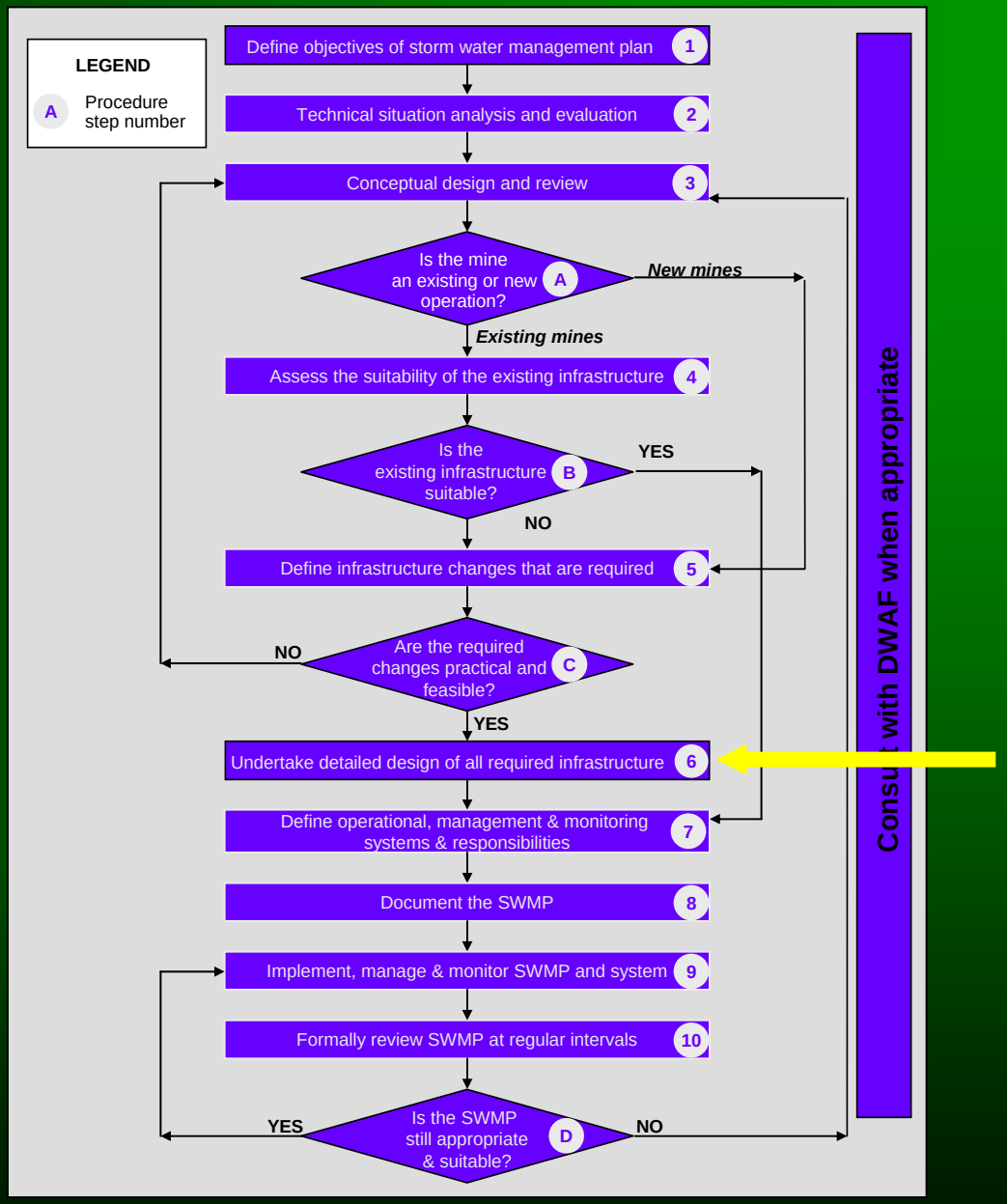
Step 5: Define Required Infrastructure Changes

- Required changes must be practically and economically feasible
- May include aspects such as construction of new pollution control dams, new stormwater diversion drains, sediment traps,
- EMP may need to be updated and EIA may be required for certain changes



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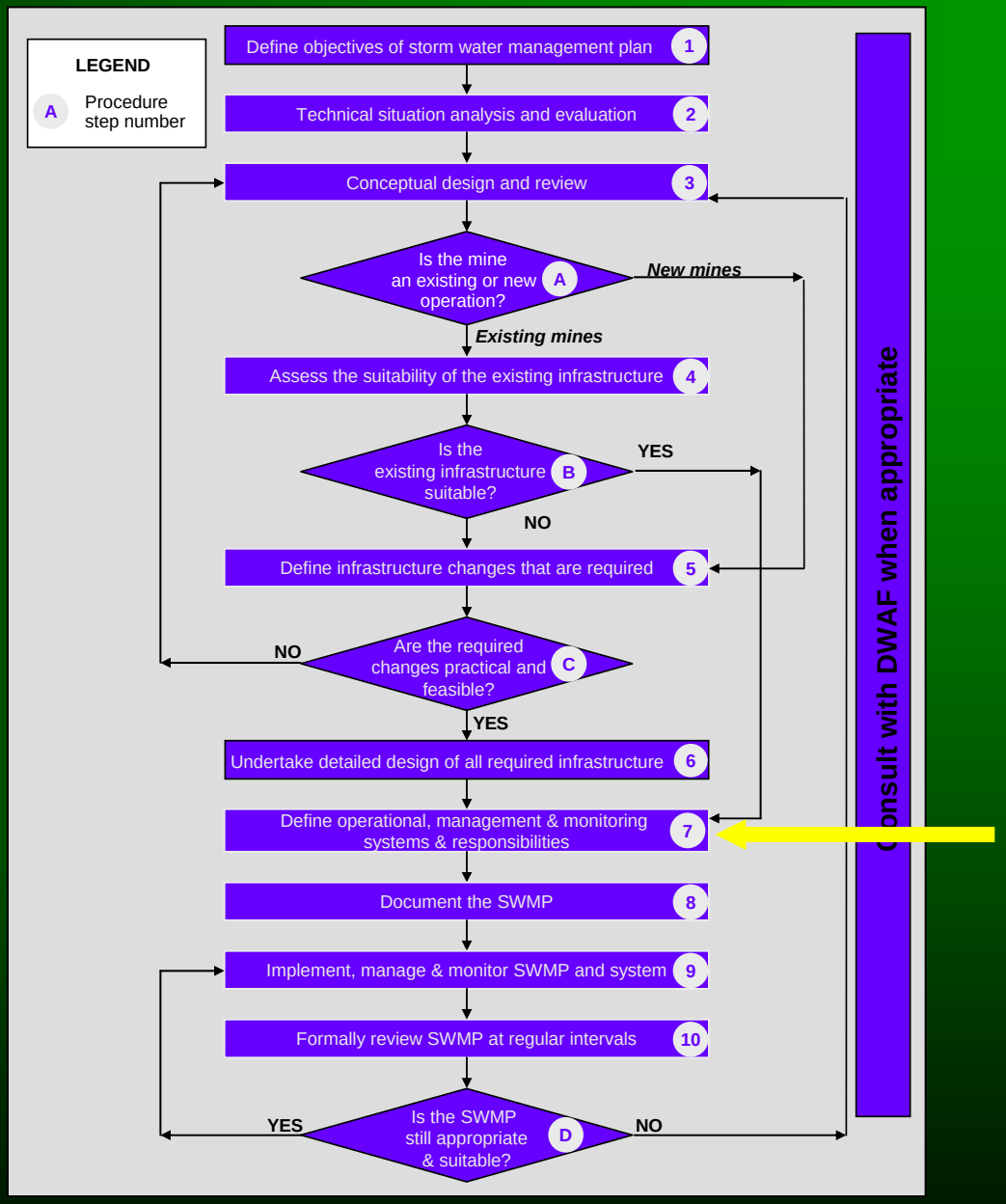
Step 6: Undertake detailed design of required infrastructure

- Design of new SWMP & Infrastructure
  - Define water quality & quantity of water users
  - Undertake hydrological calculations/modelling using appropriate models
  - Develop water balances and use to determine storage capacities to meet objectives & legislation
  - Identify and define structures needed in SWMP
  - Calculate effects of life cycle and seasonal changes
- Other aspects (rehab design; open channels; run off/routing; dams; pipelines)



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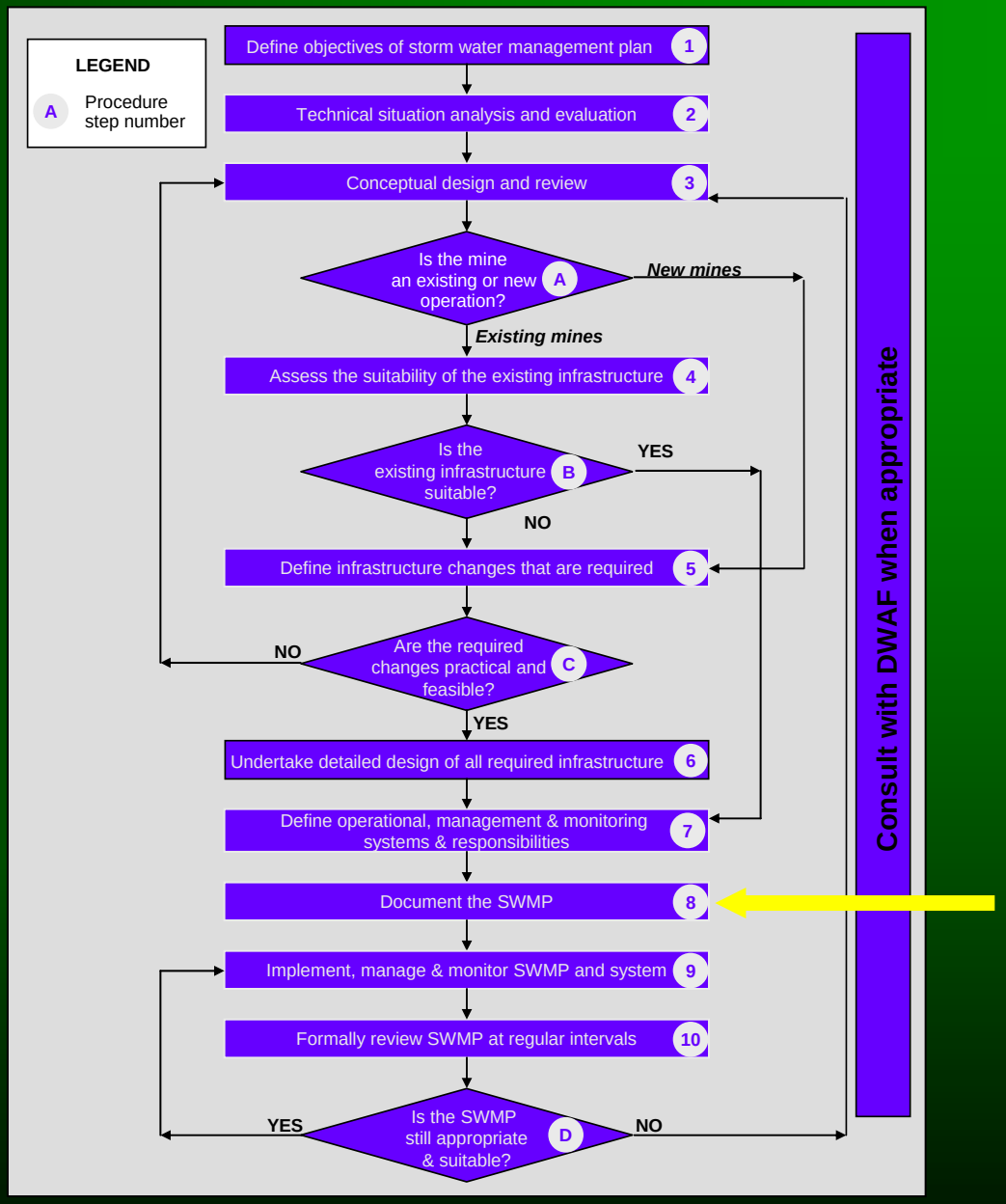
Step 7: Define operational management & monitoring systems & responsibilities

- SWMP must contain documented operational, inspection, maintenance, monitoring & emergency procedures to ensure design performance is maintained
- Regular inspections must be conducted in accordance with specified procedures
- Personnel must be allocated responsibilities and be committed to continuous improvement
- Performance checks with corrective actions to be specified



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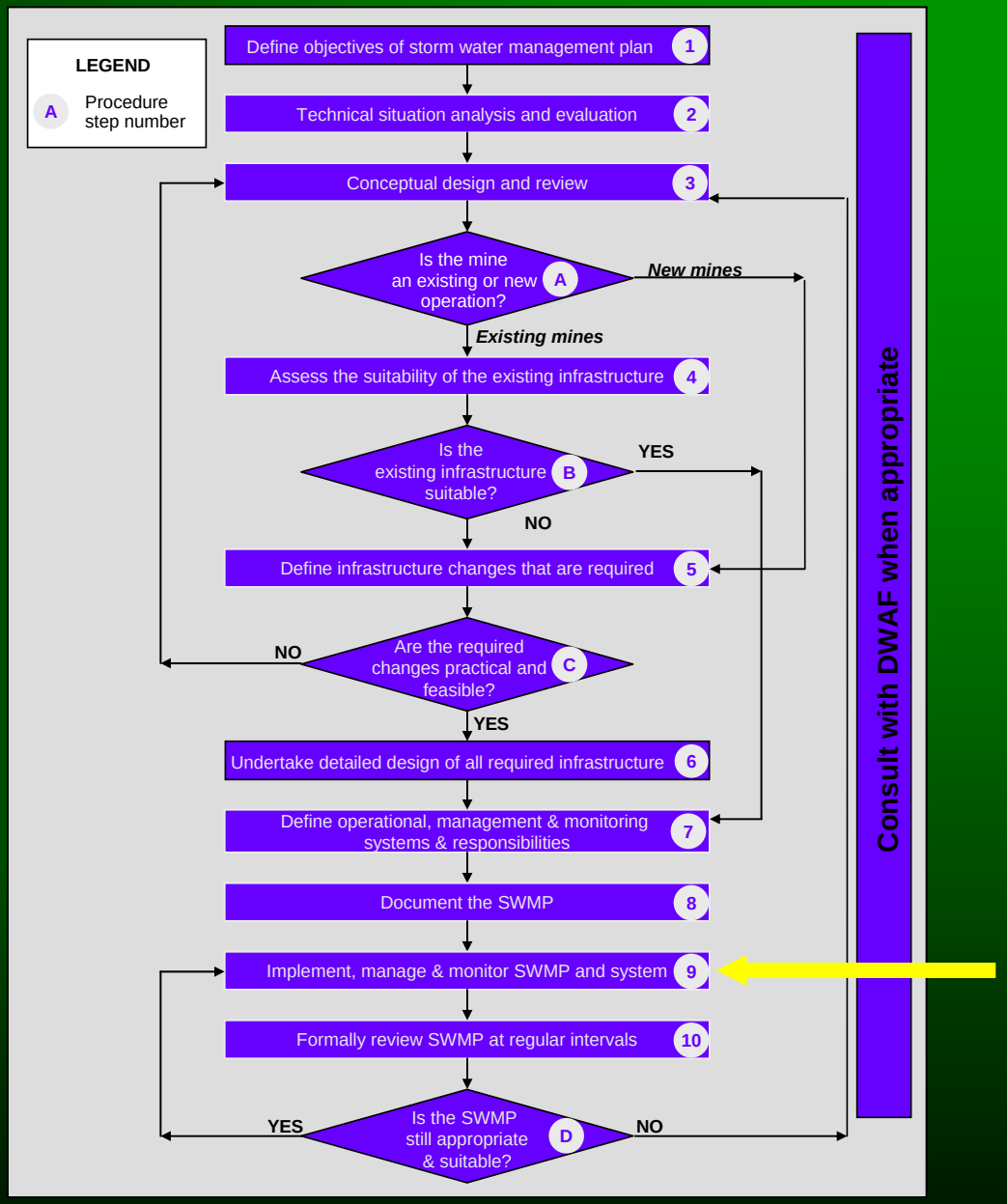
Step 8: Document the SWMP

- SWMP must be documented in appropriate format, e.g. IWMP, EMP, licence, EMS
- Must include objectives; technical procedures & studies; models used; designs and “as built” drawings; legal aspects considered; maintenance & operating procedures, monitoring programme; management structure; auditing & review procedures; emergency procedures; references



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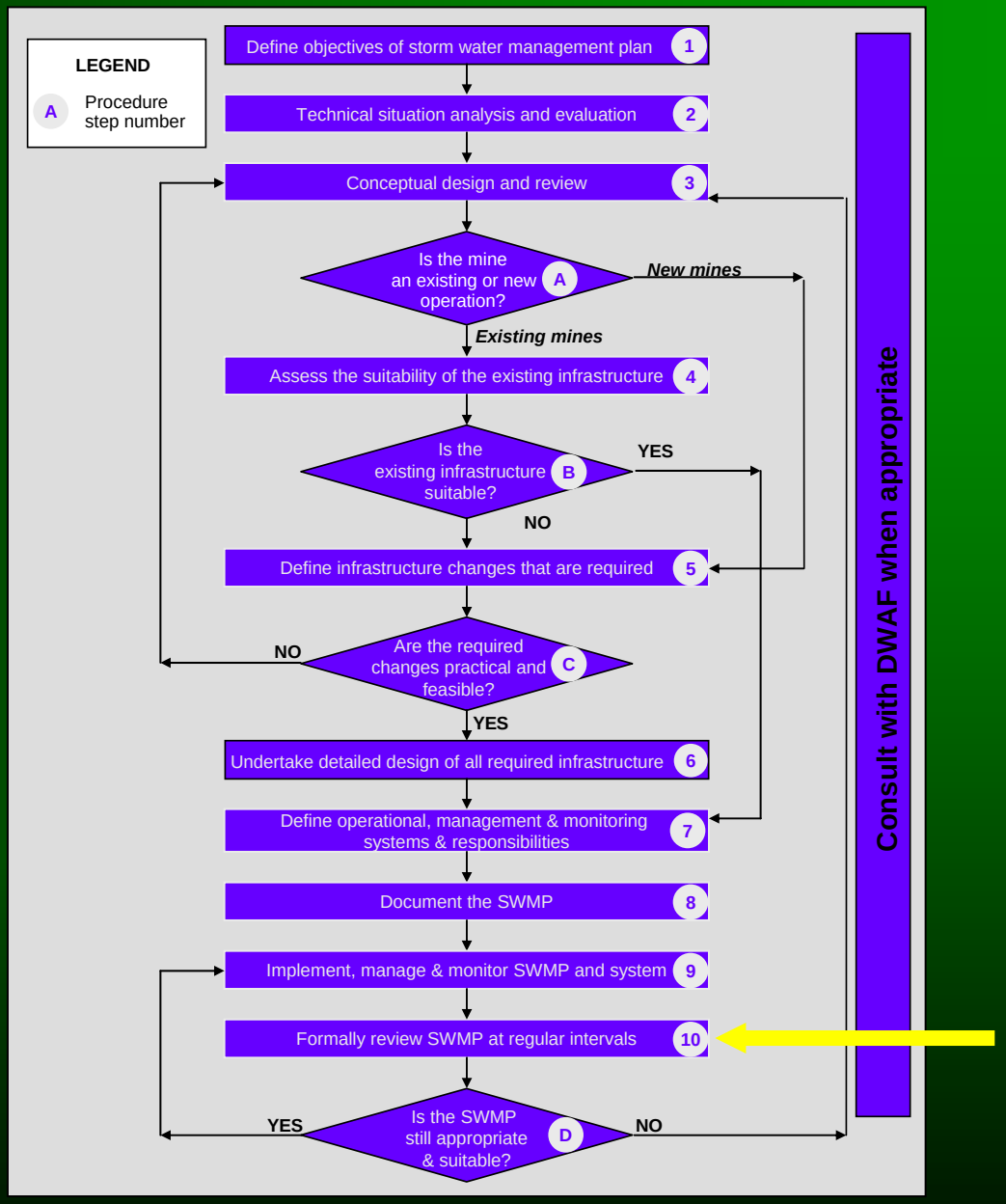
Step 9: Implement manage & monitor the SWMP

- Management & monitoring systems must be implemented and managed on ongoing basis
- SWMP to be formally reviewed at regular intervals and modified as required
- More detailed and intensive audits may be required on complex systems
- Consider regular staff training programme and R&D to improve systems



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Step 10: Formally review & audit

- In addition to routine monitoring, it is recommended to formally review SWMP and infrastructure annually for first 3 years and thereafter at regular intervals of between 1 and 3 years
- Review to focus on ensuring SWMP is still adequate in terms of changes on mine and regulations

Final components of BPG

- Useful checklist on issues to be captured in SWMP given in Table 4.3
- Review of legislative aspects
- References
- Glossary & abbreviations
- Appendices
  - A. Peak flow & flood volume determination
  - B. Computer models