LICHTENBURG LAFARGE CEMENT PLANT

STORMWATER MANAGEMENT PLAN AND GENERAL NOTICE 704 AUDIT

August 2022
REVISION 02

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SYNOPSIS

Stormwater Management Plan required as part of the Water Use Licence Application.

KEY WORDS:

Lafarge Cement Plant, National Water Act 36 of 1998, General Notice 704, Best Practice Guidelines-A1

QUALITY VERIFICATION

This report has been prepared under the controls established by a quality management system that meets the requirements of ISO9001: 2008 which has been independently certified by DEKRA Certification under certificate number 90906882

Verification	Capacity	Name	Signature	Date
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LAFARGE CEMENT PLANT STORMWATER MANAGEMENT PLAN AND GENERAL NOTICE 704 AUDIT REPORT

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1 INTRODUCTION

JG Afrika (Pty) Ltd were appointed by Lafarge Industries South Africa (Pty) Ltd to undertake a stormwater management plan (SWMP) and General Notice 704 (GN704) audit for the Lafarge Lichtenburg Cement Factory, located in the North West Province, in the year 2019. Subsequent to that study, JG Afrika have been appointed to update the stormwater management plan for the purposes of a Water Use Licence Application (WULA), and provide engineering drawings of stormwater infrastructure proposed during the initial study. The following stormwater management plan is therefore largely based on the findings of the General Notice 704 and stormwater management plan study undertaken in 2019.

Lafarge is committed to legal compliance in terms of environmental management and the philosophy of zero harm to the environment. This commitment is echoed in their Safety, Health and Environment (SHE) Policy, Lafarge values and corporate targets. To achieve full compliance, especially with regards to GN704 of the Water Act (NWA) (Act 36 of 1998), Lafarge has committed to the compilation of a comprehensive stormwater management plan.

Section 26 (1) of the NWA (Act No. 36 of 1998) provides for the development of regulations that:

- Require that the use of incoming and discharging water from a water resource be monitored, measured and recorded;
- Regulate or prohibit any activity in order to protect a water resource or in-stream or riparian habitat;
- Prescribe the outcome or effect that must be achieved through management practices for the treatment of waste, or any class of waste, before it is discharged or deposited into or allowed to enter a water resource.

GN704 (Government Gazette 20118, 4 June 1999) was drawn up to address these issues in relation to mining activities. A summary of the principal conditions from GN704, upon which the proposed SWMP is based, includes:

- **Condition 4, which describes the location of infrastructure and mining activities.** Any residue deposit, dam, reservoir, together with any associated structure must not be located within the 1:100-year floodline or within 100m of any watercourse or borehole;
- **Condition 6, which deals with capacity requirements of clean and dirty water systems.** Clean and dirty water systems must be kept separate and must be designed, constructed, maintained and operated such that these systems do not spill into each other more than once in 50 years; and

- **Condition 7, which describes the measures which must be taken to protect water resources.** All dirty water or substances which cause or are likely to cause pollution of a water resource either through natural surface flow or by seepage must be contained.

As indicated above, Condition 6 of the Regulation requires containment of clean and dirty water systems so they cannot spill into each other more than once in 50 years. To assist in planning and efficient design, this condition has been interpreted (Department of Water and Sanitation [DWS], Best Practice Guidelines - A1 [2006]) as requiring the capacity for containment of a 1:50 year storm event, over and above mean operating levels.

1.1 Declaration of Independence

JG Afrika were appointed to undertake an independent SWMP study for the Cement Plant. JG Afrika have undertaken this study in an objective manner, even if this results in views and findings that are not favourable to the Applicant or Client. JG Afrika have the expertise required to undertake the study and the resultant report presents the results in an objective manner. The main author of the report, N. Dlamini, is hydrologist at JG Afrika and has an MSc. in Hydrology. Mr. Dlamini has undertaken the SWMP study under the guidance of Mr. Phillip Hull, who is an Executive Associate and Senior Hydrologist at JG Afrika, has an MSc. in Hydrology, is professionally registered and has an excess of 14 years of relevant project experience.

2 SITE DESCRIPTION

2.1 Locality

The location of the Lafarge Cement Plant is presented in **Figure 2-1**. As depicted in this map, the cement plant is located 2 km northeast of Lichtenburg town, within the Ditsobotla Local Municipality of the North West Province. A site plan of the cement plant is provided in **Figure 2-2**.

2.2 Site Description (Mining Process)

At the cement plant, mined limestone material goes through a process of grinding and burning. Fine grinding produces a fine powder (known as raw meal). which is preheated and then sent to a Kiln. The material is heated to approximately 1 500°C before being rapidly cooled. This produces clinker, the basic material required for the production of all cements. The final manufacturing process involves cement grinding and shipping. A small amount of gypsum (3-5%) is added to the clinker to regulate how the cement will set. The mixture is then very finely ground to obtain “pure cement”. During this phase, different mineral materials, called “cement additives”, may be added alongside the gypsum. Used in varying proportions, these additives, which are of natural or industrial origin, give the cement specific properties such as reduced permeability, greater resistance to sulphates and aggressive environments, improved workability, or higher-quality finishes. Finally, the cement is stored in silos before being shipped in bulk or in bags to the sites where it will be used.

2.3 Site Assessment

As part of the study, JG Afrika conducted a site assessment of the Lafarge Cement Plant. The objective of this site assessment was to undertake a GN704 Audit and to gain an understanding of the current state of stormwater management at the plant. This included recording the size and location of stormwater management infrastructure. JG Afrika were accompanied by employees of the cement factory to assist in identifying stormwater channels. In addition to physically measuring the stormwater infrastructure, Lafarge employees provided information on areas of concern where flooding has historically occurred.

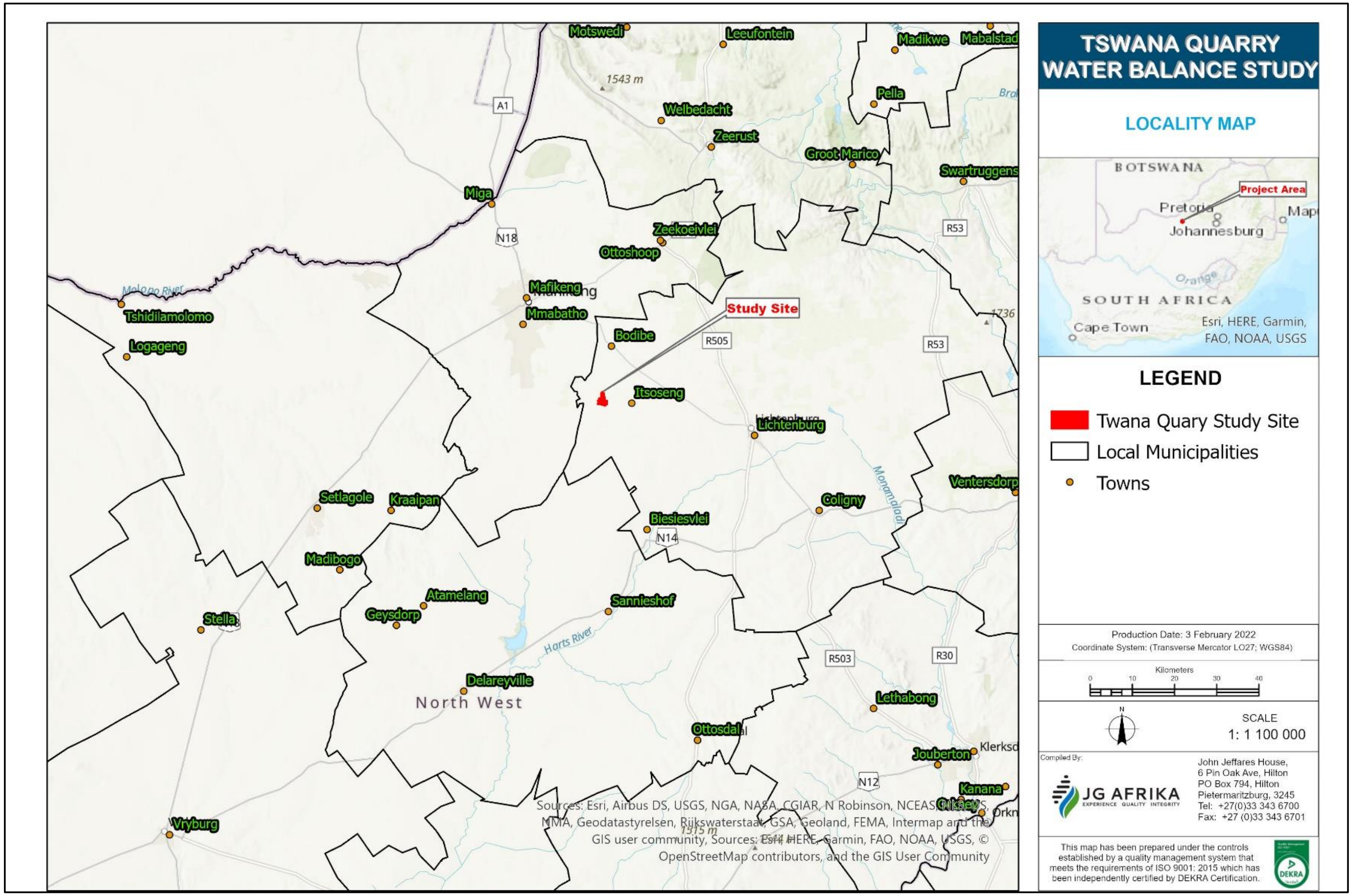

Figure 2-1 Lafarge Cement Plant

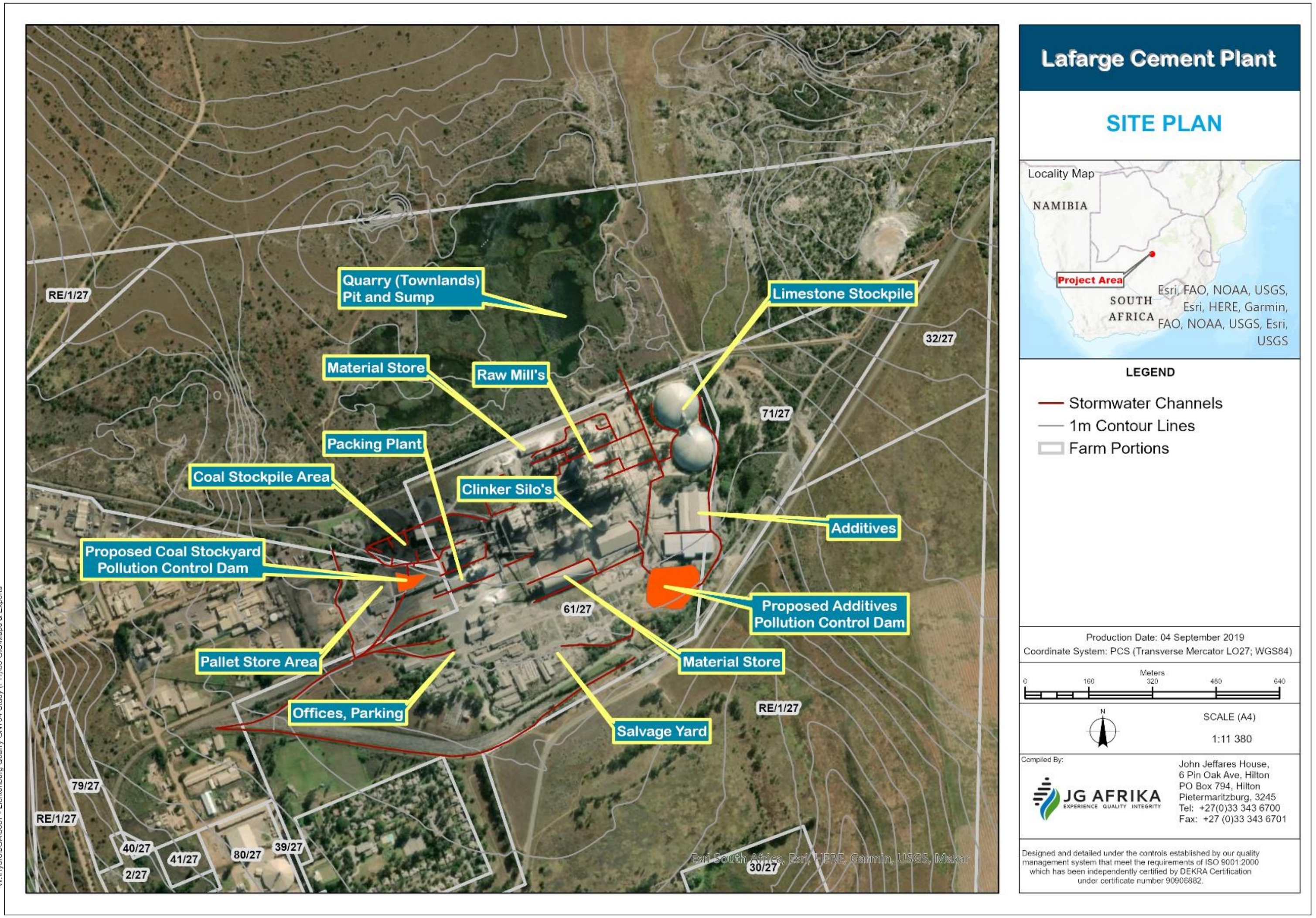

Figure 2-2 Lafarge Cement Plant Site Plan

3 STORM WATER MANAGEMENT PLAN METHODOLOGY

An effective storm water management system is essential to ensure operations at the cement plant are uninterrupted and to protect the downstream water resources. As presented previously, the main objective of the SWMP is to ensure that the risk of polluting water resources downstream of the Lafarge Cement Plant site are minimised. This entails the management of dirty water generated at the cement plant, stockpile areas, overburden stockpile areas and fuel and hydrocarbon stores.

The DWS Best Practice Guidelines (BPGs)-A1 (2006), which were developed specifically for stormwater management in small-scale mining, was used as a basis for the assessment and recommendations provided as part of this study. These guidelines are based on the requirements of GN704. The basic principles of a SWMP, which were followed in this study, are outlined below:

1. Clean water must be kept clean and be routed to a natural watercourse by a system separate from the dirty water system, while preventing, or minimising, the risk of spillage of clean water into dirty water systems.
2. Dirty water must be collected and contained in a system separate from the clean water system and the risk of spillage, or seepage, into clean water systems must be minimised.
3. The SWMP must be sustainable over the life cycle of the dirty areas, over different hydrological cycles and it must incorporate principles of risk management.
4. The statutory requirements of various regulatory agencies and the interests of stakeholders must be considered and incorporated.

In order for the SWMP to be compliant with statutory requirements, the sizing of the stormwater management infrastructure was assessed based on the 1:50 year return period storm event. For this purpose, the Rational Method was used to calculate peak discharge values, used in the sizing of the stormwater infrastructure (i.e. diversion berms and channels), while the Soil Conservation Service – South Africa (SCS-SA) method was used to size the proposed Pollution Control Dam (PCD) at the Lafarge Cement Plant. One of the main inputs in Deterministic Methods for peak discharge calculations (such as the Rational and SCS-SA Methods) is design rainfall. The following section presents the design rainfall values used in this study.

3.1 Design Rainfall

Design rainfall for the site was obtained from the Design Rainfall Estimation Program (Smithers and Schulze, 2003). This Design Rainfall Estimation software calculates the design rainfall depths using a regionalised L-moment Algorithm and scale invariance at any 1’ × 1’ grid interval in South Africa. The software returned similar design rainfall values at both sites. The design rainfall depths for various durations, used in the calculation of the 1:50 year return period design flood peaks, are presented in **Table 3-1**.

Table 3-1 1:50 Year Return Period Design Rainfall Values

Duration	1:50 Year Design Rainfall Depths (mm)
5 min	20.3
10 min	30.2
15 min	38.0
30 min	48.2
45 min	55.3
1 hour	61.0
1.5 hour	70.0
2 hour	77.2
4 hour	90.2
6 hour	98.8
8 hour	105.4
10 hour	110.9
12 hour	115.5
16 hour	123.2
20 hour	129.6
24 hour	135.0
2 day	138.1
3 day	155.8
4 day	169.0
5 day	180.0
6 day	189.5
7 day	198.0

3.2 Rational Method Description

The Rational Method is widely used throughout the world for both small rural and urban catchments (Alexander, 2001; Pilgrim and Cordery, 1993) and is the most widely used method of estimating design flood peak discharge values. The peak flow equation is based on a runoff coefficient (C), average rainfall intensity (I) and the effective area of the catchment (A).

The Rational formula is defined as:

$$Q = 0.278(CIA) \qquad \textbf{Equation 1}$$

Where:

Q	=	peak flow (m^3/s)
C	=	run-off coefficient (dimensionless)
I	=	average rainfall intensity over catchment (mm/hour)
A	=	effective area of catchment (km^2)

The Rational formula has the following assumptions:

- The rainfall has a uniform spatial distribution across the total contributing catchment;
- The rainfall has a uniform time distribution for at least a duration equal to the time of concentration;
- The peak discharge occurs when the total catchment contributes to the flow occurring at the end of the critical storm duration, or time of concentration;
- C remains constant for the storm duration, or the time of concentration; and
- The return period of the peak flow, T, is the same as that of the corresponding rainfall intensity.

Catchment C Factors, required as input into the Rational Method, are determined by accounting for a combination of catchment landcover types (C_v), soils (C_p) and slope (C_s). Catchment C Factors applied to each respective catchment area is provided in **Section 4**.

4 STORMWATER MANAGEMENT PLAN ASSESSMENT

The following chapter presents the results of the SWMP assessment for the Lafarge Cement Factory. As presented previously, all recommendations pertaining to the size and capacity of stormwater infrastructure have been based on the 1:50 year design flood. The method used to calculate the 1:50 year peak discharge values was the Rational Method, as described in **Section 3.2**.

Due to the extent of the Lafarge Cement Plant, the plant area has been subdivided into five areas, largely pertaining to different catchment areas and discharge points associated with the project site, as presented in **Figure 4-1**. In summary, the focal areas for the GN704 Audit and SWMP at the Lafarge Lichtenburg Cement Plant include:

- Area A - The Dispatch, Temporary Storage, Packing Plant, Cement Silos, Fly-Ash Silos, Gypsum Offload, Workshop, Wash Bay, Offices and Railway Sidings Areas located on the western portion of the property.
- Area B - The Coal Stockpile, Cement Silos, Fly-Ash Silos and Gypsum Offload Area located in the central area of the property.
- Area C - The Electrical Substation, Fire-Tank and Fuel Storage area located along the northern portion of the property.
- Area D - The Raw Mills, Kilns, Limestone Domes, Clinker Silos, China Town (materials store) and Additives Storage areas in the central and south eastern area of the project site.
- Area E - Materials, sediment and general dump area along the north eastern portion of the project site, where the unnamed stream traverses the project site.

4.1 Area A Stormwater Management Plan Assessment

As mentioned above and presented in **Figure 4-1**, Area A consists of Dispatch, Temporary Storage, Packing Plant, Cement Silos, Fly-Ash Silos, Gypsum Offload, Workshop, Wash Bay, Offices and Railway Sidings Areas. The Stormwater runoff from Area A flows in a westerly direction, reporting to Channel A9 (as presented in **Figure 4-2**), located adjacent to the railway line, and eventually discharging into a tributary of the Harts River.

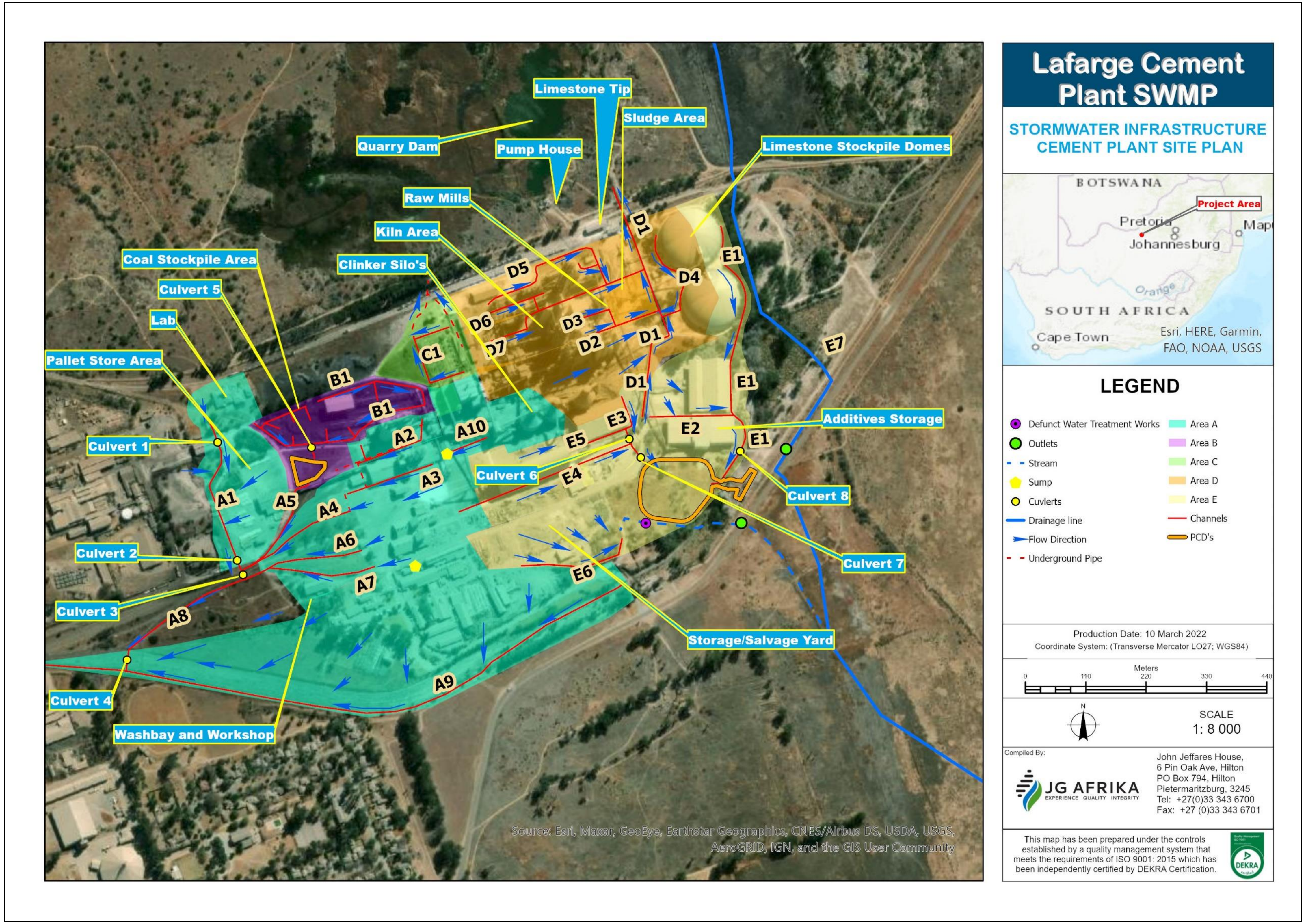

Figure 4-1 Lafarge Lichtenberg Cement Plant Focal Areas GN704 Audit and Conceptual SWMP Assessment Areas

As part of the stormwater management assessment, the location and dimensions of stormwater management infrastructure were noted where possible. The identified stormwater channels in Area A are presented in **Figure 4-2**. Due to Area A of the cement plant being located on a ridge, there is no requirement for clean stormwater runoff diversions. Channel A10 in **Figure 4-2** will carry water to a sump which is then be pumped into Channel A2.

A summary of the catchment characteristics contributing flows to each of the respective channels is presented in **Table 4-1**. Based on the calculated 1:50 year peak discharge value, the compliance assessment is presented in **Table 4-2**. If channels were found to be inadequately sized, recommendations were made on revised channel dimensions, and these are presented in **Table 4-3**. Culvert recommendation for road crossings at stormwater channels are presented in **Table 4-4**.

Table 4-1 Area A Stormwater Channel Design Flood Calculation Results

Channel	Catchment Area (km^2)	Time of Concentration (hrs)	Catchment C Factor	1:50 Year Design Rainfall (mm)	1:50 Year Peak Discharge (m^3/s)
A1	0.04	0.51	0.48	47	0.52
A2	0.01	0.25	0.50	152	0.20
A3	0.01	0.25	0.50	152	0.17
A4	0.04	0.63	0.44	82	0.41
A5	0.04	0.52	0.36	94	0.42
A6	0.01	0.25	0.34	152	0.17
A7	0.03	0.50	0.34	78	0.35
A8	0.16	1.14	0.73	63	1.70
A9	0.37	2.25	0.43	35	1.77
A10	0.03	0.43	0.69	44	0.50
A1, A4 and A5	0.11	1.04	0.79	58	1.25

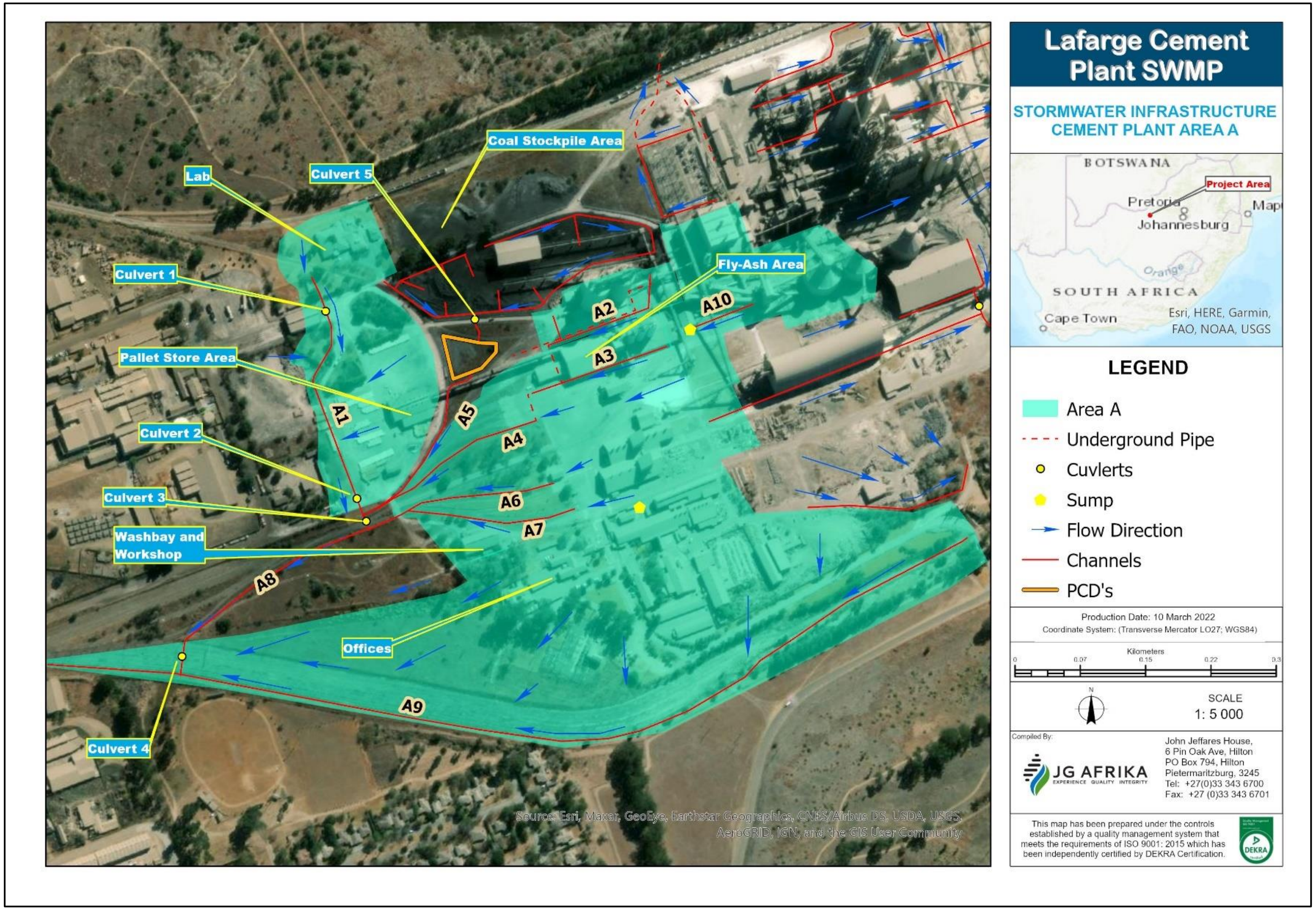

Figure 4-2 Lafarge Lichtenberg Cement Plant Stormwater Channels – Area A

Table 4-2 Area A Stormwater Channel Size and Compliance Assessment

Channel	Shape	Top Width (m)	Bottom Width (m)	Depth (m)	Channel Capacity	Compliance
A1	Sedimented / Blocked/Non-existent				Unknown	Non-compliant
A2	Square	0.45	0.45	0.90	0.31	Compliant
A3	Square	0.45	0.45	0.90	0.31	Compliant
A4	Irregular	Not Applicable			Unknown	Non-compliant
A5	Portions Sedimented / Blocked				Unknown	Non-compliant
A6	Irregular	Not Applicable			Unknown	Non-compliant
A7	Trapezoidal	5	1.50	1.50	10.80	Compliant
A8	Irregular	Not Applicable			Unknown	Non-compliant
A9	Irregular	Not Applicable			Unknown	Non-compliant

Table 4-3 Recommended Stormwater Channel Dimensions for Area A

Channel	Shape	Side Slope	Top Width (m)	Bottom Width (m)	Depth (m)
A1	Trapezoidal (Concrete lined)	1:1.5	2.10	0.60	0.50
A4	Trapezoidal (Concrete lined)	1:1.5	1.40	1.00	0.40
A5	Trapezoidal (Concrete lined)	1:1.5	2.10	0.60	0.50
A6	Trapezoidal (Concrete lined)	1:1.5	1.40	1.00	0.40
A8	Trapezoidal (Grass lined)	1:3	3.30	0.60	0.45
A9	Trapezoidal (Grass Lined)	1:3	3.30	0.60	0.45
A10	Trapezoidal (Concrete lined)	1:1.5	1.70	0.60	0.27

Table 4-4 Recommended Pipe Culvert Sizes

Channel	Shape	Span (m)	Rise (m)	Deck Height (m)	Openings	Capacity (m^3/s)	Required Peak (m^3/s)
Culvert 1	Pipe	0.45	0.30	0.06	1	0.15	0.13
Culvert 2	Box	0.45	0.45	0.09	2	0.56	0.52
Culvert 3	Box	0.45	0.60	0.12	3	1.12	0.95
Culvert 4	Box	0.45	0.90	0.15	3	1.96	1.70

4.2 Area B – GN 704 Audit and SWMP Assessment

As depicted in **Figure 4-1**, Area B consists predominantly of the Coal Stockpile area. Currently, stormwater runoff from this area either discharges to the environment to the north of the cement plant (from the portion of the Coal Stockyard north of the access road) or it discharges in a southerly direction (portion of the Coal Stockyard south of the access road), into the stormwater channels around the Cement and Fly-Ash Silos and into Channels A4 and A5, as depicted in **Figure 4-2**.

The area of the Coal Stockyard is considered a source of potential contamination to the downstream environment. As such, GN704 stipulations require that all stormwater runoff from the Coal Stockyard area is kept separate from clean stormwater runoff areas, with the likelihood of spills from the Coal Stockyard area not likely to occur more than once in fifty years. Currently, no dirty stormwater management infrastructure was noted in the area of the Coal Stockyard. This is in contravention to GN704 and is therefore non-compliant. A depiction of the Coal Stockyard area is presented in **Plate 4-4**.

Plate 4-4 *Illustration of the Lack of Stormwater Management Infrastructure near the Coal Stockyard*

Due to limited stormwater management infrastructure in the vicinity of the Coal Stockpile, the following is proposed from a stormwater management perspective:

- The area in which coal is stored on site should be minimised as far as possible. Through reducing the area in which the coal is stored, the volume of water that needs to be managed on site (prevented from being discharged to the downstream environment) will be reduced. It was noted from discussions with Lafarge that the area to the north of the access road will no longer be used to store coal. This area is to be rehabilitated and therefore is not considered further in the recommendations for stormwater management around Area B.

- It is recommended that the Coal Stockyard area is lined (to prevent contamination to the groundwater systems). It should be noted that by reducing the area associated with the Coal Stockyard, the costs associated with lining the Coal Stockyard and the capacity requirements of the downstream PCD are reduced.
- A stormwater channel is recommended to be constructed around the perimeter of the Coal Stockyard, with fish-bone drains extending from the perimeter channel into the coal stockyard. The purpose of this channel is to contain stormwater runoff from Coal Stockyard as well as to ensure that pooling of stormwater within the stockyard area is prevented.
- Stormwater channels along the perimeter of the coal stockyard are proposed to direct stormwater runoff to the Coal Stockyard PCD, as illustrated in **Figure 4-3**.

Stormwater Channel Capacity Recommendations

It should be noted, based on the recommendations provided in this report, preliminary level designs of proposed stormwater channels have been detailed in an engineering design report (*5707 - Lichtenburg Lafarge Cement Plant and Tswana Quarry Stormwater Infrastructure and Pollution Control Dams Preliminary Design Report*). Engineering Drawings of the proposed stormwater infrastructure are also included in **Annexure A**.

A summary of the catchment characteristics contributing flows to channel B1 and the estimated catchment capacities of the internal channels leading off Channel B are presented in **Table 4-6**. Based on the calculated 1:50 year peak discharge value, the proposed stormwater channel around the coal stockyard is presented in **Table 4-7**. The recommended pipe culvert size is presented in **Table 4-8**.

Table 4-5 Area B Stormwater Channel Design Flood Calculation Results

Channel	Catchment Area (km^2)	Time of Concentration (hrs)	Catchment C Factor	1:50 Year Design Rainfall (mm)	1:50 Year Peak Discharge (m^3/s)
B1	0.005	0.61	0.90	57.41	0.10
B2	0.013	1.12	0.90	70.57	0.18
B3	0.001	0.31	0.90	45.48	0.03

Table 4-6 Proposed Stormwater Channel Dimensions Around the Coal Stockyard

Channel	Shape	Top Width (m)	Bottom Width (m)	Depth (m)	Side Slope (m/m)
B1	Trapezoidal	1.65	0.60	0.35	1:2
B2	Trapezoidal	1.65	0.60	0.35	1:2
B3	Triangular	4.20	0	0.35	1:6

Figure 4-3 Lafarge Lichtenberg Cement Plant – Coal Stockyard Area Stormwater Management – Area B

Table 4-7 Recommended Pipe Culvert Sizing

Channel	Shape	Span	Rise	Deck Height (m)	Openings	Capacity (m^3/s)	Required Peak (m^3/s)
Culvert 5	Box	0.45	0.45	0.09	2	0.55	0.40

Coal Stockyard Pollution Control Dam Recommendations

It should be noted, based on the recommendations provided in this report, preliminary level designs of the PCD's have been provided in a detailed in an engineering design report (*5707 - Lichtenburg Lafarge Cement Plant and Tswana Quarry Stormwater Infrastructure and Pollution Control Dams Preliminary Design Report*). Engineering Drawings of the proposed stormwater infrastructure are included in **Annexure A**. In addition to this, a detailed water balance study has been undertaken to determine the required storage volume of the Coal Stockyard PCD. A separate report detailing the methodology for the compilation of the water balance has been compiled (*5707 - Lichtenburg Lafarge Cement Plant – Water Balance Study Report*).

As presented previously, GN704 states that clean and dirty water systems must be designed, constructed, maintained and operated such that they do not spill into each other more than once in 50-years, and that all dirty water, or substances which are likely to cause pollution of a water resource, are contained. In order to achieve this, a daily water balance of the coal stockyard PCD has been configured for the period 1950 to 1999. Therefore, recommendations pertaining to the PCD are based on 50 years of daily simulated inflows and outflows from the dam. For the purposes of determining a capacity of the PCD, the requirement to limit spills to no more than one spill in 50-years has been interpreted to mean that no more than one day of spillage over the 50-year simulation period is allowed.

In order for the PCD to function, it is assumed that water will be reused as process water within the cement plant. As part of the analysis, iterations of the volume of water that would/should hypothetically be returned to the plant were simulated. Depending on the average volume of water returned to the plant on a daily and monthly basis, the required capacity of the PCD changes (as with higher volumes of water returned, the less likely there is to be a spill from the dam and therefore a lesser storage capacity is required). A summary of the results of these iterations, and the associated required PCD capacities based on the assumption that the water will be used in the plant, are provided in **Table 4-9**. Due to the limited area in which the PCD is to be constructed (limited by the location of railway lines), the capacity that the dam can be constructed is also limited. Based on discussions between the PCD design engineers and Lafarge Management, it was agreed that the Coal Stockyard PCD should have a minimum full supply capacity of 4 000 m^3. Based on this capacity, the volume of water that should be used in the cement plant, in order to ensure that the dam will not spill, equates to 67 m^3/day.

Table 4-8 Iterations of PCD Capacities Versus Water to be Returned to the Cement Plant

PCD Storage Volume (m^3)	Return Water Per Month (m^3)	Return Water Per Day (m^3)
2000	5400	178
2500	3672	120
3000	2570	85
3500	2184	72
4000*	2031*	67*
4500	1910	63
5000	1758	58

*Selected PCD storage and daily return water volume

4.3 Area C –Stormwater Management Plan Assessment

As presented in **Figure 4-4**, Area C includes stormwater runoff from the Electrical Substation, Fire Tank and Fuel Storage areas. Stormwater from these areas discharges in a northerly direction, through an underground stormwater channel, toward the Quarry (Townlands) Pit Sump.

Due to the fact that the fuel tanks are located in a bunded area (see **Plate 4-5**), the potential hydrocarbon contamination sources in the substation area are bunded (see **Plate 4-5**) and the area north of the Sub-Station area is unlikely to contaminate surface water resources. The catchment pertaining to Area C is considered a clean stormwater runoff area. During the site assessment it was, however, noted that there are significant quantities of fine sediment in the area around the fuel tank. The source of these fine sediments was not known. In order to maintain its status as a clean stormwater catchment area (therefore avoiding the requirement of storing and/or treating stormwater runoff prior to discharge), all fine sediment located in this area needs to be removed to an area designated for storage of waste materials. This needs to be undertaken regularly so that there is never a build-up of waste (fine sediment), which could negatively impact upon the downstream environment.

As presented in **Plate 4-6**, it was found that a number of the stormwater channels in Area C were poorly maintained and had vegetation growing within the channels. This will result in a decrease in the capacity of the stormwater channels. It is therefore recommended that all stormwater channels in this area are cleared of sediment and vegetation at least bi-annually.

Plate 4-5 Illustration of Bunded Fuel Tank and Bunded Sub-Station Areas

Plate 4-6 Examples of Poorly Maintained Stormwater Channels

As mentioned previously, the stormwater management assessment included documenting the location and dimensions of stormwater management infrastructure. The identified stormwater channels in Area C are presented in **Figure 4-4**. Due to Area C of the cement plant being located on a ridge, there is no requirement for clean stormwater runoff diversions in this area.

A summary of the catchment characteristics contributing flows to each of the respective channels is presented in **Table 4-9**. Based on the calculated 1:50 year peak discharge value, the compliance assessment is presented in **Table 4-10**.

Table 4-9 Area C Stormwater Channel Design Flood Calculation Results

Channel	Catchment Area (km^2)	Time of Concentration (hrs)	Catchment C Factor	1:50 Year Design Rainfall (mm)	1:50 Year Peak Discharge (m^3/s)
C1	0.03	0.50	0.38	48.24	0.28

Table 4-10 Area C Stormwater Channel Size and Compliance Assessment

Channel	Shape	Top Width (m)	Bottom Width (m)	Depth (m)	Channel Capacity	Compliance
C1	Trapezoidal	1.23	0.75	1.2	1.06	Compliant

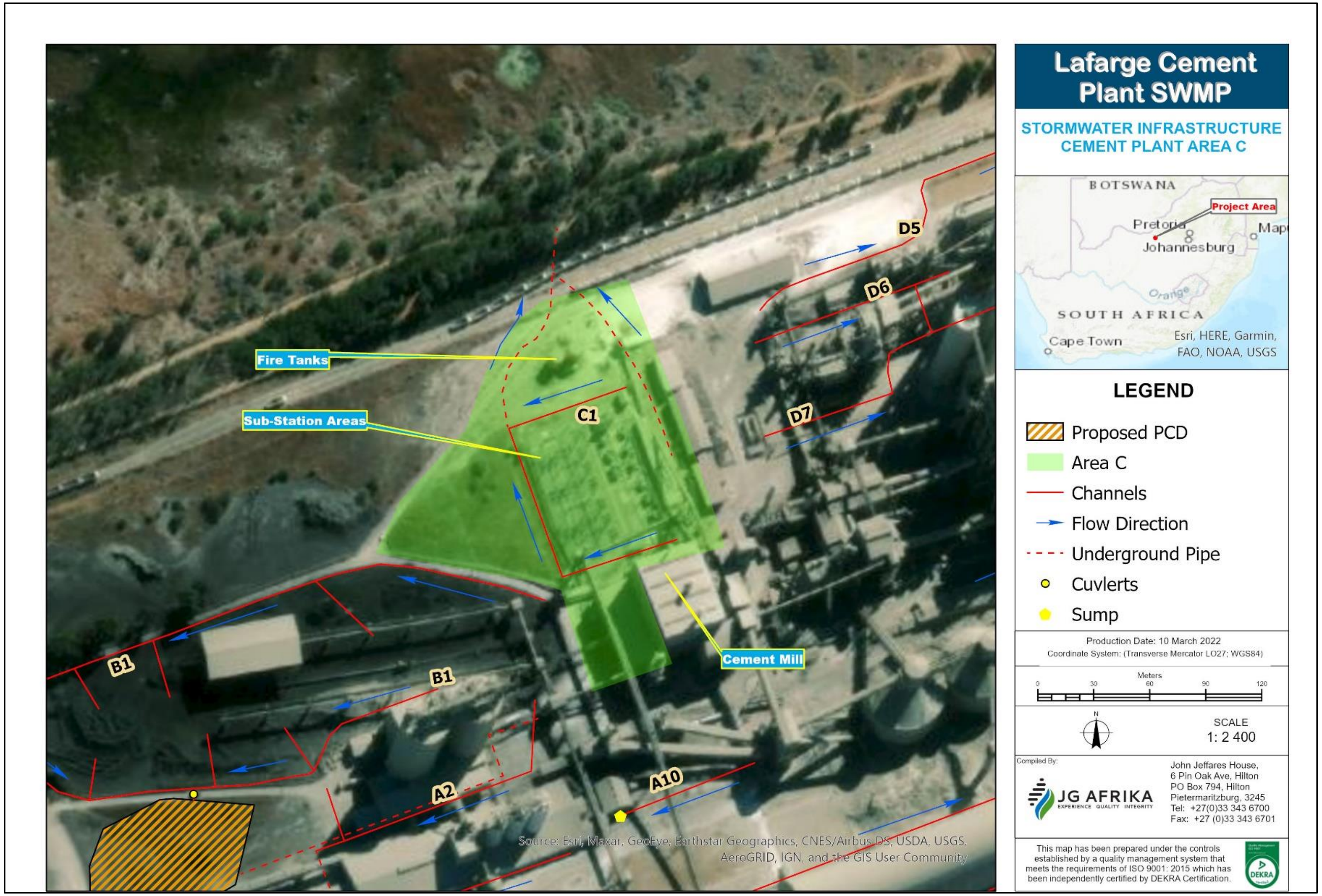

Figure 4-4 Lafarge Lichtenberg Cement Plant Stormwater Channels – Area C

4.4 Area D – Stormwater Management Plan Assessment

As presented in **Figure 4-5**, Area D consists Raw Mills, Kiln, Cement Mills, Clinker Silos and the China Town (materials store) areas. Stormwater runoff from these areas reports to Channel D1C (as presented in **Figure 4-5**), which then discharges in a northerly direction into the Quarry Sump.

The area contributing flows to Channel D1 is relatively large and consists predominantly of hardened surfaces within the main process area of the cement plant. The main concern for stormwater management in this area pertains to excessive volumes of fine sediment, noted during the site assessment. This has resulted in the majority of stormwater channels in Area D being partially or fully blocked, as depicted in **Plate 4-7**. The chemical characteristics (and therefore risk of contamination) of the fine material is not known, however, it is noted that stormwater runoff from this area will be contained within the Quarry Sump, which is endorheic (i.e. there are no points of surface water discharge from the dam). It is recommended that water quality sampling is undertaken, particularly from Channel D1 (last channel before the Quarry Sump), to determine the risk of chemical contamination of the water resources in the Quarry Sump. During the site assessment, no sources of hydrocarbon contamination were noted within the Area D catchment.



Plate 4-7 Illustration of Poorly Maintained and Blocked Stormwater Channels in the China Town Area

As mentioned previously, the stormwater management assessment included documenting the location and dimensions of stormwater management infrastructure. The identified stormwater channels in Area D are presented in **Figure 4-5**. Due to Area D of the cement plant being located on a ridge, there is no requirement for clean stormwater runoff diversions in this area.

A summary of the catchment characteristics contributing flows to each of the respective channels is presented in **Table 4-11**. Based on the calculated 1:50 year peak discharge value, the compliance assessment is presented in **Table 4-12**. If channels were found to be inadequate, recommended channel dimensions are presented in **Table 4-13**. As presented in **Table 4-13**, the only channel to be found non-compliant was channel D1a as it was full of sediment at the time of the assessment. It is therefore recommended sediment currently blocking this channel is removed and the channel reinstated. If the channel is found to be smaller than that recommended in **Table 4-13**, this channel may then need to be re-designed and re-constructed.

Table 4-11 Area D Stormwater Channel Design Flood Calculation Results

Channel	Catchment Area (km^2)	Time of Concentration (hrs)	Catchment C Factor	1:50 Year Design Rainfall (mm)	1:50 Year Peak Discharge (m^3/s)
D1a	0.04	0.61	0.60	50.89	0.56
D1b	0.07	0.67	0.60	52.56	0.92
D1c	0.09	0.77	0.60	55.39	1.11
D2	0.03	0.43	0.50	45.50	0.45
D3	0.01	0.37	0.50	43.05	0.18
D4	0.02	0.39	0.18	43.22	0.13
D5	0.02	0.53	0.47	49.09	0.20
D6	0.01	0.25	0.50	38.00	0.11
D7	0.04	0.47	0.50	47.17	0.55

Table 4-12 Area D Stormwater Channel Size and Compliance Assessment

<table>
<tr><th>Channel</th><th>Shape</th><th>Top Width (m)</th><th>Bottom Width (m)</th><th>Depth (m)</th><th>Channel Capacity</th><th>Compliance</th></tr>
<tr><td>D1a</td><td colspan="4">Sedimented / Blocked</td><td></td><td>Unknown</td></tr>
<tr><td>D1b</td><td rowspan="2">Trapezoidal</td><td rowspan="2">1.34</td><td rowspan="2">0.9</td><td rowspan="2">1.1</td><td rowspan="2">1.11</td><td rowspan="2">Compliant</td></tr>
<tr><td>D1c</td></tr>
<tr><td>D2</td><td rowspan="2">Trapezoidal</td><td rowspan="2">2.75</td><td rowspan="2">2</td><td rowspan="2">0.25</td><td rowspan="2">0.5</td><td rowspan="2">Compliant</td></tr>
<tr><td>D3</td></tr>
<tr><td>D5</td><td>Trapezoidal</td><td>1.34</td><td>0.9</td><td>1.1</td><td>1.11</td><td>Compliant</td></tr>
<tr><td>D6</td><td>Trapezoidal</td><td>2.75</td><td>2</td><td>0.25</td><td>0.5</td><td rowspan="2">Compliant</td></tr>
<tr><td>D7</td><td>Trapezoidal</td><td>1.34</td><td>0.9</td><td>1.1</td><td>1.11</td></tr>
</table>

Table 4-13 Area D Recommended Stormwater Channel Dimensions

Channel	Shape	Top Width (m)	Bottom Width (m)	Depth (m)
D1a	Trapezoidal	1.00	0.60	0.95

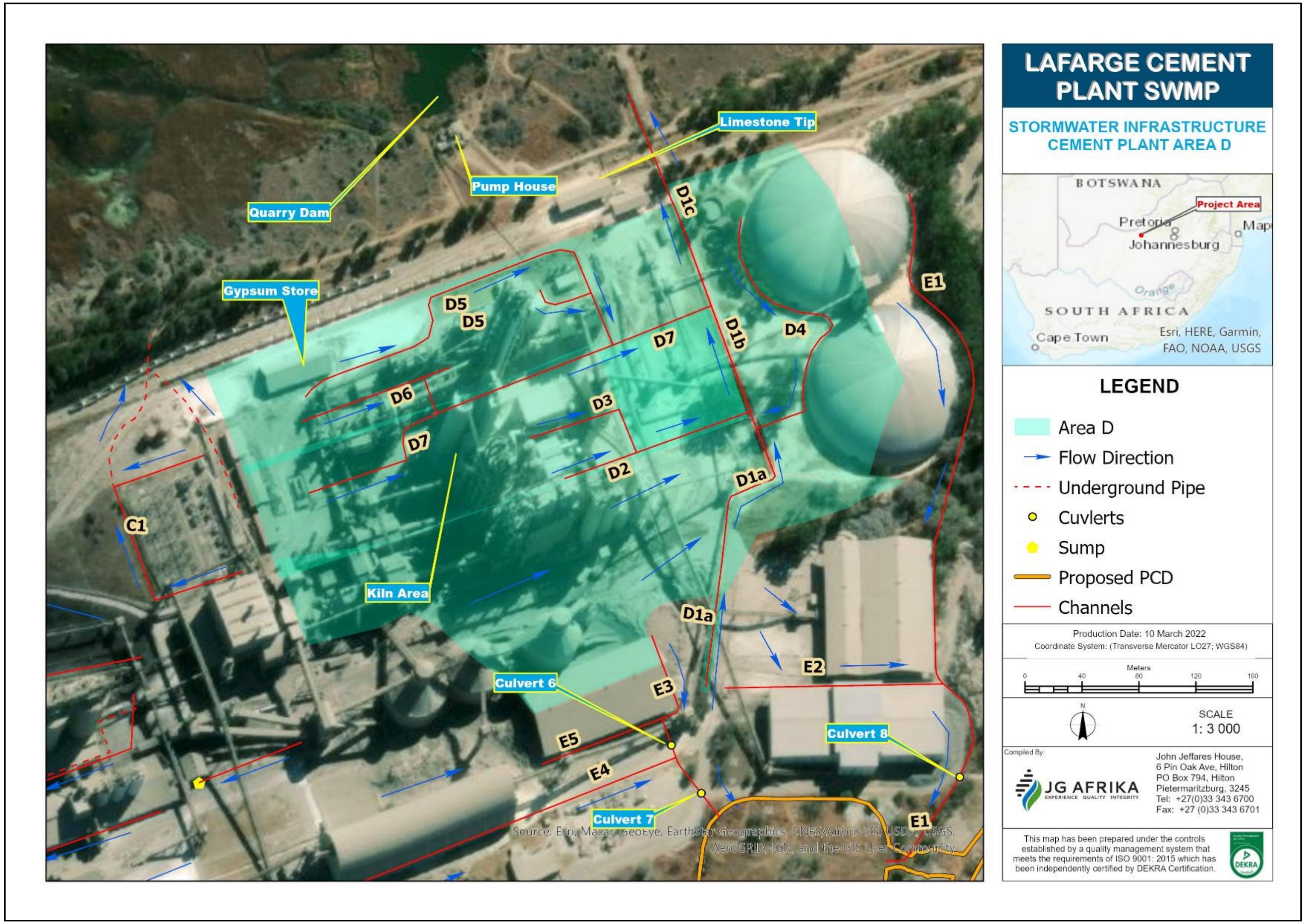

Figure 4-5 Lafarge Lichtenberg Cement Plant – Area D

4.5 Area E – Stormwater Management Plan Assessment

As presented in **Figure 4-1** and **4-6**, Area E consists of the south eastern and eastern portion of the cement plant property. This area consists of the Salvage Yard, defunct Water Treatment Works, Additive Storage and the Limestone Dome areas. Stormwater discharges from this portion of the site are in a southerly direction.

Within the salvage yard area, it was noted that a significant number of oil drums (some empty and some containing used oil) are located outside of a bunded area. In order to ensure that hydrocarbon contamination of the downstream water resources is avoided, all oil drums on site (and any other sources of hydrocarbon contamination) needs to be stored within a bunded and lined area. Oil stores, including used oil drums, need to have a storage capacity within the bunded area, exceeding the volume of hydrocarbons being stored in the area. They also need to be sign posted, have access control and be roofed, if possible. Due to the high number of oil drums noted to be located on site, it is recommended that the oil drums are appropriately disposed of and/or recycled.

Based on information provided by the Client, it was noted that although the Additive Storage is located under a roofed structure, it is possible that additives may spill outside of the designated storage areas. Evidence of this was noted during the site assessment, where fine sediment (thought to originate from the additives stockpiles) was found in the main stormwater channel, as presented in **Plate 4-8**. It was also noted, based on information provided by the Client, that the additives may result in contamination to the downstream environment. Based on this, the area around the Additives Storage is considered as a dirty stormwater runoff catchment. Therefore, as presented below, stormwater runoff from this area should report to a pollution control dam. It is noted that Vanchem Magnetite, Bauxite, Zimalco Aluminium Dross, Silica sand and Pozz Sand (Fly Ash) are stored in the additives area.

 

Plate 4-8 Illustration of Blocked Channels in the Additives Storage Areas

Stormwater Infrastructure Assessment

As mentioned previously, the stormwater management assessment included documenting the location and dimensions of stormwater management infrastructure. The identified stormwater channels in Area E are presented in **Figure 4-6**. This includes proposed alterations to the stormwater system to direct stormwater from the Additives Area, secondary coal storage area (around channels E3 and E5) and Limestone Domes to a proposed PCD, as presented in **Figure 4-6**.

A summary of the catchment characteristics contributing flows to each of the respective channels is presented in **Table 4-14**. Based on the calculated 1:50 year peak discharge value, the compliance assessment is presented in **Table 4-15**. If channels were found to be inadequate, recommended channel dimensions are presented in **Table 4-16**. The recommended dimensions for culverts where the stormwater channels intersect with roads are presented in **Table 4-17**.

Table 4-14 Area E Stormwater Channel Design Flood Calculation Results

Channel	Catchment Area (km^2)	Time of Concentration (hrs)	Catchment C Factor	1:50 Year Design Rainfall (mm)	1:50 Year Peak Discharge (m^3/s)
E1a	0.03	0.30	0.42	39.75	0.25
E1b	0.04	0.30	0.49	39.75	0.60
E2	0.03	0.36	0.90	42.59	0.37
E3a	0.003	0.25	0.90	37.74	0.11
E3b	0.025	0.25	0.80	37.74	0.84
E4	0.01	0.38	0.90	42.96	0.37
E5	0.01	0.25	0.90	37.74	0.29
E6	0.03	0.38	0.47	43.39	0.42

Table 4-15 Area E Stormwater Channel Size and Compliance Assessment

Channel	Shape	Top Width (m)	Bottom Width (m)	Depth (m)	Channel Capacity (m^3/s)	Compliance
E1a	Proposed Channel					
E1b	Proposed Channel					
E2	Proposed Channel					
E3a	Proposed Channel					
E3b	Proposed Channel					
E4	Sedimented / Blocked				Unknown	Non-compliant
E5	Trapezoidal	3.30	1.20	0.30	0.49	Compliant
E6	Rectangle	1.35	1.35	0.80	1.34	Compliant

Table 4-16 Area E Recommended Stormwater Channel Dimensions

Channel	Shape	Top Width (m)	Bottom Width (m)	Depth (m)
E1a	Trapezoidal	1.50	0.60	0.30
E1b	Trapezoidal	2.40	0.60	0.31
E2	Trapezoidal	1.50	0.60	0.30
E3	Trapezoidal	1.50	0.60	0.30
E3a	Trapezoidal	4.20	0.60	0.30
E4	Trapezoidal	1.52	0.60	0.23

Table 4-17 Recommended Pipe Size of Culvert

Channel	Shape	Span	Rise	Deck Height (m)	Openings	Capacity (m^3/s)	1:50 Year Peak (m^3/s)
Culvert 6	Box	0.60	0.60	0.12	1	0.56	0.51
Culvert 7	Box	0.45	0.45	0.11	3	0.87	0.84
Culvert 8	Box	0.45	0.60	0.09	2	0.73	0.60

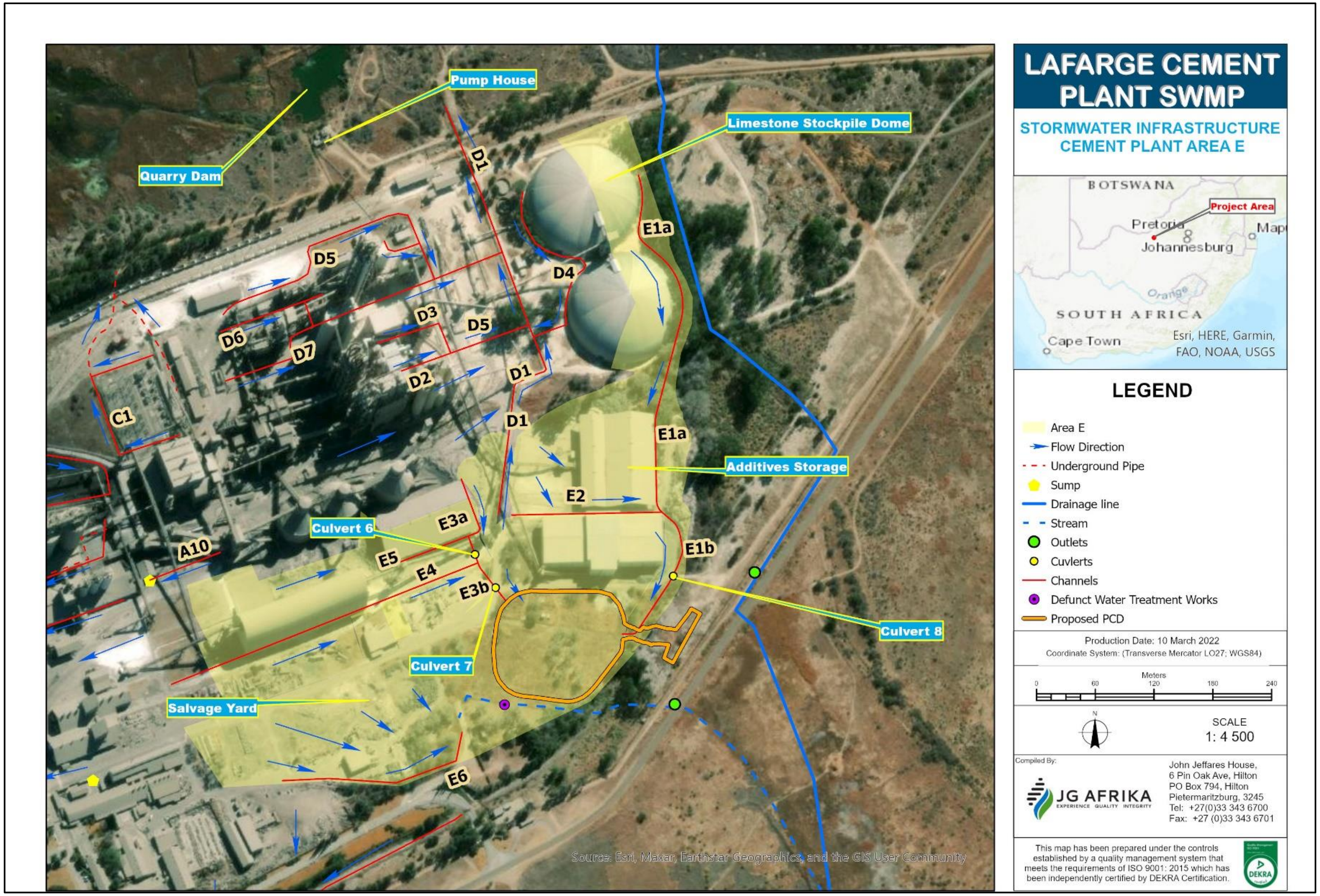

Figure 4-6 Lafarge Lichtenberg Cement Plant – Area E

Additives Area Pollution Control Dam Recommendations

Based on the recommendations provided in this report, preliminary level designs of the Additives PCD have been documented in a detailed engineering design report (*5707 - Lichtenburg Lafarge Cement Plant and Tswana Quarry Stormwater Infrastructure and Pollution Control Dams Preliminary Design Report*). Engineering Drawings of the proposed stormwater infrastructure are included in **Annexure A**.

A detailed water balance study has been undertaken to determine the required storage volume of the Additives PCD. A separate report detailing the methodology for the compilation of the water balance is provided in report (*5707 - Lichtenburg Lafarge Cement Plant – Water Balance Study Report*).

As presented previously, GN704 states that clean and dirty water systems must be designed, constructed, maintained and operated such that they do not spill into each other more than once in 50 years, and that all dirty water, or substances which are likely to cause pollution of a water resource, are contained. In order to achieve this, a daily water balance of the Additives PCD has been configured for the period 1950 to 1999. Therefore, recommendations pertaining to the PCD are based on 50 years of daily simulated inflows and outflows from the dam. For the purposes of determining a capacity of the PCD, the requirement to limit spills to no more than one spill in 50-years has been interpreted to mean no more than one day of spillage over the 50-year simulation period.

In order for the PCD to function, it is assumed that water from the Additives PCD will be reused as process water within the cement plant. As part of the analysis, iterations of the volume of water that would/should hypothetically be returned to the plant were simulated. Depending on the average volume of water returned to the plant on a daily and monthly basis, the required capacity of the PCD changes (as with higher volumes of water returned, the less likely there is to be a spill from the dam and therefore a lesser storage capacity is required). A summary of the results of these iterations, and the associated required PCD capacities based on the assumption that the water will be used in the plant, are provided in **Table 4-18**. Based on discussions between the PCD design engineers and Lafarge Management, it was agreed that the Additives PCD should have a minimum full supply capacity of 20 000 m^3. Based on this capacity, the volume of water that should be used in the cement plant, in order to ensure that the dam will not spill, equates to 316m^3/day.

Table 4-18 Iterations of PCD Capacities Versus Water to be Returned to the Cement Plant

PCD Storage Volume (m^3)	Return Water Per Month (m^3)	Return Water Per Day (m^3)
15 000	11 725	386
17 500	10 350	341
20 000*	9 625*	316*
22 500	8 853	292
25 000	8 322	274
27 500	7 656	252
30 000	7 044	232
35 000	5 855	193

*Selected PCD storage and daily return water volume

5 CONCLUSION AND RECOMMENDATIONS

The objective of this study was to assess stormwater management at the Lichtenberg Lafarge Cement Plant, located on portion 61 of Lichtenburg Town Farm No 27. The cement plant was assessed in terms of compliance with GN704 of the NWA and recommendations were made in order for the stormwater management at the plant to be compliant with GN704.

Due to the extent of the Lafarge Cement Plant, the stormwater management assessment was subdivided into five areas. These areas were largely defined according to catchment areas and stormwater runoff discharge points around the plant. A summary of the identified issues related to GN704 requirements and the SWMP assessment, for the cement plant, are as follows:

- Generally, it was noted that maintenance of stormwater infrastructure in and around the plant was poor. Numerous channels were partially or fully blocked by sediment. This results in the channels becoming ineffective in managing stormwater runoff, which in turn has resulted in flooding of certain portions of the study area. It was therefore recommended that all stormwater channels are excavated. In addition to this, minimum channel size requirements were provided as part of this study. The proposed channel sizes are based on the 1:50 year return period design flood event (as per GN704 requirements).
- Area A consists of Dispatch, Temporary Storage, Packing Plant, Cement Silos, Fly-Ash Silos, Gypsum Offload, Workshop, Wash Bay, Offices and Railway Sidings Areas. The Stormwater runoff from Area A flows in a westerly direction, reporting to a channel located adjacent to the railway line, and eventually discharging into a tributary of the Harts River. A number of channels in this area were found to be blocked or undersized. Therefore, recommendations on the dimensions of the proposed infrastructure were made.
- Stormwater management around the Coal Stockyard (Area B) was found to be insufficient. Currently there are no interventions implemented to prevent contamination of the downstream environment through runoff from the Coal Stockyard area. It was therefore recommended that a channel is constructed around the perimeter of the Coal Stockyard. It was also recommended that a PCD is constructed downstream of the Coal Stockyard area. Preliminary designs of the PCD have been undertaken, and are presented in a separate report (*5707 - Lichtenburg Lafarge Cement Plant and Tswana Quarry Stormwater Infrastructure and Pollution Control Dams Preliminary Design Report*). Based on a detailed water balance of the proposed PCD, using 50 years of daily rainfall data extending from 1950 to 1999, the proposed capacity of the PCD is 4 000 m^3. In order to ensure that the dam is unlikely to spill more than

once in 50 years, a daily average of 67 m^3/day of water stored in the dam needs to be recycled back into the process water stream in the plant. This water may require treatment, depending on the water quality requirements of the plant process water.

- Area C includes stormwater runoff from the Electrical Substation, Fire Tank and Fuel Storage areas. Stormwater from these areas discharges in a northerly direction, through an underground stormwater channel, toward the Quarry (Townlands) Pit. No stormwater infrastructure interventions are proposed for Area C.
- Area D consists Raw Mills, Kiln, Cement Mills, Clinker Silos and the China Town (materials store) areas. The catchment area associated with Area D is relatively large and consists predominantly of hardened surfaces within the main process area of the cement plant. The main concern for stormwater management in this area pertains to excessive volumes of fine sediment, noted during the site assessment. This has resulted in the majority of stormwater channels in Area D being partially or fully blocked. The chemical characteristics (and therefore risk of contamination) of the fine material is not known, however, it is noted that stormwater runoff from this area will be contained within the Quarry sump, which is endorheic (i.e. there are no points of surface water discharge from the dam). It is recommended that water quality sampling is undertaken, particularly from the channel leading to the Quarry Sump, to determine the risk of chemical contamination of the water resources in the Quarry Sump.
- Area E consists of the south eastern and eastern portion of the cement plant property. This area consists of the Salvage Yard, defunct Water Treatment Works, Additive Storage and the Limestone Dome areas. Stormwater currently discharges from this portion of the site are in a southerly direction. Based on information provided by the Client, it was noted that although the Additive Storage is located under a roofed structure, it is possible that additives may spill outside of the designated storage areas. Evidence of this was noted during the site assessment, where fine sediment (thought to originate from the additives stockpiles) was found in the main stormwater channel. It was also noted, based on information provided by the Client, that the additives may result in contamination to the downstream environment. Based on this, the area around the Additives Storage is considered as a dirty stormwater runoff catchment. Based on this, stormwater runoff from this area should report to a pollution control dam. It was therefore recommended that several channels are constructed around the Additives area to direct stormwater runoff to an Additives PCD. Preliminary designs of the PCD have been undertaken, and are presented in a separate report (*5707 - Lichtenburg Lafarge Cement Plant and Tswana Quarry Stormwater Infrastructure and Pollution Control Dams Preliminary Design Report*). Based on a detailed water balance of the proposed PCD,

using 50 years of daily rainfall data extending from 1950 to 1999, the proposed capacity of the PCD is 20 000 m^3. In order to ensure that the dam is unlikely to spill more than once in 50 years, a daily average of 316 m^3/day of water stored in the dam needs to be recycled back into the process water stream in the plant. This water may require treatment, depending on the water quality requirements of the plant process water.

- Measures implemented for the prevention of hydrocarbon contamination of water resources and the receiving environment, in the area of the Wash Bay and Workshop (adjacent to the Wash Bay) was found to be insufficient. Hydrocarbon spills outside of bunded areas were evident during the site assessment. Recommendations to prevent future contamination included refurbishment and rehabilitation of the oil separator located adjacent to the Wash Bay and Workshop.
- Oil drums (some empty and some containing used oil) were noted to be located outside of defined, bunded oil storage areas. Due to the large number of oil drums on site, it was recommended that discarded oil drums are disposed of or recycled appropriately. Otherwise all oil drums need to be stored in a defined (fenced and sign posed) and bunded area (where the risk of hydrocarbon contamination is minimal).

6 REFERENCES

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ANNEXURE A – PRELIMINARY DESIGN DRAWINGS