Appendix C2 – Groundwater

Introduction

As part of the Drain London project Drain London Tier 1 consultants commissioned Jacobs/JBA to produce a dataset referred to as the Increased Potential Elevated Groundwater (iPEG) maps. The assessment was carried out at a Greater London scale. The iPEG mapping assists in identifying areas which have an increased potential to experience groundwater flooding. The iPEG map shows those areas within the borough where there is an increased potential for groundwater to rise to within 2m of the ground surface. When groundwater rises to this level water may be able to enter below ground structures such as basements and communications networks and continue rising to cause surface water flooding. The iPEG map includes an assessment of the potential groundwater to rise in both consolidated aquifers and from superficial permeable deposits (unconsolidated aquifers). The map also includes those areas close to rivers which are underlain by permeable superficial deposits where groundwater may rise to elevated levels driven by high water levels in the river.

Methodology

Large areas within the Drain London area are underlain by permeable substrate and thereby have the potential to store groundwater. Under some circumstances groundwater levels can rise and cause flooding problems in subsurface structures or at the ground surface. The mapping technique described below aims to identify only those areas in which there is the greatest potential for this to happen.

Four data sources have been utilised to produce the increased Potential for Elevated Groundwater map. These data sources are the:

- British Geological Survey (BGS) Groundwater Flood Susceptibility Map;
- Jacobs Groundwater Emergence Maps (GEMs);
- Jeremy Benn Associates (JBA) Groundwater Flood Map; and
- Environment Agency/Jacobs Thames Estuary 2100 (TE2100) groundwater hazard maps.

To produce the iPEG map for consolidated aquifers, an area was defined as having increased potential for elevated groundwater levels if at least two of the three mapping techniques listed above produced a corresponding area. For the permeable superficial deposits, only Band 1 Very High of the BGS and the TE2100 data were used as this was judged to best represent the hazard.

A description of each of the four data sets and how it was used in the production of the iPEG map is summarised in Table 1 below. The iPEG map should be viewed with careful consideration of the strengths and disadvantages of each of the four data sets.

Table 1 Summary of Data Used in the Production of the iPEG Map

	BGS Groundwater Flood Susceptibility Map	Jacobs Groundwater Emergence Map	JBA Groundwater Flood Map	Jacobs TE2100 Groundwater Maps
Mechanisms considered / hydrogeological coverage	Clearwater flooding through all consolidated aquifers and groundwater flooding through Permeable Superficial Deposits (PSD)	All major consolidated aquifers	Unconfined Chalk and Permeable Superficial Deposits	Groundwater emergence in Permeable Superficial Deposits in hydrological continuity with river levels.
Methodology	• Identify from geology where groundwater flooding could not occur • For all other areas, produce a groundwater level surface from National Groundwater Level data, modified to best represent groundwater flooding • Compare the groundwater level surface with the DTM and determine susceptibility to groundwater flooding based on depth to groundwater	Three scenarios: • Where flooding was reported and groundwater contours were available, groundwater emergence zones were defined such that they encompassed incidents of observed flooding. • Where no flooding was reported or no data supplied, but groundwater contours were available, then groundwater emergence zones were based on generalised aquifer properties and observation borehole levels. • Where no groundwater contour information was available, river network classified by BFIHOST was used to identify susceptible areas	For the Chalk maps: • Develop water level – frequency relationships at available boreholes • Extrapolate this relationship to un-gauged locations • Compare water level surface with DTM for mapped events	• Identify from geology areas of permeable superficial deposits • Identify mean water level in the Thames Estuary (and tidal watercourses) which will drive the groundwater head • Determine likely distance from the estuary (and tidal watercourses) over which groundwater levels could be influenced • Identify areas where the groundwater level could rise to the level in the estuary and be within 2m of the ground surface

	BGS Groundwater Flood Susceptibility Map	Jacobs Groundwater Emergence Map	JBA Groundwater Flood Map	Jacobs TE2100 Groundwater Maps
Data used in the production of the maps	BGS 1:50 000 geological mapping, with classifications of permeability, NextMap 5m DTM, National Groundwater Level data on a 50m grid.	50m resolution IHDTM; groundwater contour data from EA and BGS for all major aquifer units from various dates; borehole level data; recorded observations of groundwater flooding from 2000/1.	Borehole records from the EA; 5m DTM from Infoterra and 1:625 000 scale geological mapping	BGS 1:50 000 geological mapping, LiDAR data at 2m resolution and information on mean water levels and defence crest heights.
Strengths	• Considers consolidated and superficial aquifers • Based on National Groundwater Level data • Calibrated on winter 2000/1 observations of flooding • Provides number of classes of susceptibility to indicate sensitivity • Could select only highest susceptibility bands	• Calibrated on winter 2000/1 observations of flooding	• Provides explicit representation of 1 in 100 chance outline • Provision of up to three event probabilities could enable sensitivity testing • Calibrated on winter 2000/1 observations of flooding	• Considers an important mechanism not considered by other methods • Important mechanism in east London.
Disadvantages	• Outlines are not explicitly linked to event probabilities • Maps may indicate overly-large areas as susceptible to groundwater flooding	• Does not consider PSD • Outlines are not explicitly linked to event probabilities • Regional scale	• PSD map based on 1:50k background.	• Determination of distance from estuary over which groundwater levels could be influenced could be improved • Could consider an upward slope on groundwater levels away from the estuary

How to Use and Interpret the Map

The increased Potential for Elevated Groundwater map shows those areas within the borough where there is an increased potential for groundwater to rise sufficiently to interact with the ground surface or be within 2 m of the ground surface.

Groundwater may become elevated by a number of means:

- Above average rainfall for a number of months in Chalk outcrop areas;
- Shorter period of above average rainfall in permeable superficial deposits;
- Permeable superficial deposits in hydraulic continuity with high water levels in the river;
- Interruption of groundwater flow paths; and
- Cessation of groundwater abstraction causing groundwater rebound.

With the exception of groundwater rebound which is not covered, the iPEG map will identify those areas most prone to the mechanisms described above. The map shows those areas considered to have the greatest potential for elevated groundwater. Additional areas within the London Boroughs have permeable geology and therefore could also produce elevated groundwater levels. However, to produce a realistic map, only where there is the highest degree of confidence in the assessment are the areas delineated. This ensures resources are focused on the most susceptible areas. In all areas underlain by permeable substrate, groundwater should still be considered in planning developments.

Within the areas delineated, the local rise of groundwater will be heavily controlled by local geological features and artificial influences (e.g. structures or conduits) which cannot currently be represented. This localised nature of groundwater flooding compared with, say, fluvial flooding suggests that interpretation of the map should similarly be different. The map shows the area within which groundwater has the potential to emerge but it is unlikely to emerge uniformly or in sufficient volume to fill the topography to the implied level. Instead, groundwater emerging at the surface may simply runoff to pond in lower areas.

For this reason within iPEG areas, locations shown to be at risk of surface water flooding are also likely to be most at risk of runoff/ponding caused by groundwater flooding. Therefore the iPEG map should not be used as a "flood outline" within which properties at risk can be counted. Rather it is provided, in conjunction with the surface water mapping, to identify those areas where groundwater may emerge and if so what would be the major flow pathways that water would take.