Appendices

A. Construction Cost Estimates by Robert Martell and Partners

St Raphaels Estate, Neasden

	Summary of Cost Estimates		Total		No units	Ave cost per unit
1	**New Build Units & Roof Extensions**		98,010,844		608	161,202
2	**Refurbishment of Existing Housing Units**		28,899,000	126,909,844	741	39,000
3	**Community Facilities**		3,123,500			
4	**External Works & Community Spaces**		16,691,250			
5	**Upgrade of Services**		1,000,000	20,814,750		
				147,724,594		
6	**Contingency Sum**	5%		7,386,230		
				155,110,824		
7	**Allowance for Professional Fees**	12%		18,613,299		
				£173,724,123		126,991

Notes

VAT - not included (zero on new-build, positive on alterations)

Solar PV panels etc not included

Prices as 1Q 2021 allowed

No allowance for s106 fees

No allowance for planning or building regs. fees

St Raphaels Estate, Neasden

Cost Estimates for New Build Units & Roof Extensions

Type		Description	Housing Types	M2 per unit	maisonettes	flats	Blocks	houses	Cost per block or house	Total	No. units in total
A		New build flats alongside North Circular	3-4 bed maisonettes (3 per block)	120	120		6		2,512,864	15,077,184	18
			8 no 2 bed flats in each block)	70		48			inc		48
			4 no 1 bed flats in each block)	50		50			inc		24
B	**1**	New build houses along the park	2 story 3-4 bed houses	100				30	163,000	4,890,000	30
	2	New build houses along the park	2 story 3 bed houses	88				16	143,440	2,295,040	16
	3	New build houses along the park	2 story 3-4 bed houses	100				24	163,000	3,912,000	24
	4	New build houses along creek	3-4 bed houses	100				12	163,000	1,956,000	12
C	**1**	Flat block (above possible community space)	2 bed flats	70		12	1		1,613,400	1,613,400	12
	2	Flat block	2 bed flats	70		8	1		1,230,000	1,230,000	8
	3	infill blocks	2 bed flats	70		12	1		1,699,000	1,699,000	12
	4	infill blocks (ground floor)	3 bed maisonettes	100		5	1		1,070,500	1,070,500	5
	5	flats over	2 bed flats	70		16	1		2,211,000	2,211,000	16
D		flats over residents social club	2 bed flats	70		28	1		3,939,000	3,939,000	28
E	**1**	maisonettes along estate Northern edge	3 bed maissonettes	120	120		19		521,400	9,906,600	57
	2	flats over maisonettes along estate Northern edge	2 bed flats	85		85			inc		
F	**1**	Infill adjacent to and access to Type 1 flat blocks and roof extensions	flats mixed	80		80	10		1,038,800	10,388,000	50
	2	general infill (houses - to imitate existing)	3bed 2 storey houses	110				20	179300	3,586,000	20
G	**1**	along creek	3 storey 2 bed flats	70		30	10		420,000	4,200,000	30
J	**1**	8 story flats over civic space - in tower	1, 2, 3 bed flats/ maisonettes	70		17	1		2,574,050	2,574,050	17
	2	2 story maisonettes over civic space	2 bed maisonettes	83	83			3	160,190	480,570	3
Proposed Roof Extensions											
H	**1**	Roof extensions on type 1	2 bed maisonettes	83	144				160,190	23,067,360	144
	2	Roof extensions on type 2 (above shops)	2 bed maisonettes	83	83			6	160,190	961,140	6
	3	Roof extensions on type 5	1 bed flats	50		50		28	105,500	2,954,000	28
		Total								£98,010,844	608

St Raphaels Estate, Neasden

Cost Estimates for New Build Units

Type		Description	Housing Types	M2 per unit	flats	floors	houses	maisonettes	No per Block	GIFA	Rate /m2		Founds	Roof	Lifts, £ 30k/floor/ lift (x2)	Total per block	Total per house
A		New build flats alongside North Circular	3-4 bed maisonettes (3 per block)	120		6		120	3	360	1675	603,000	115,584	161,280	360,000	2,512,864	
			8 no 2 bed flats in each block	70	48				8	560	1675	938,000					
			4 no 1 bed flats in each block	50	50				4	200	1675	335,000					
B	1	New build houses along the park	2 story 4 bed houses	100			30			3000	1630	4,890,000	inc	inc	nil		163,000
	2	New build houses along the park	2 story 3 bed houses	88			16			1408	1630	2,295,040					143,440
	3	New build houses along the park	2 story 3 bed houses	100			24			2400	1630	3,912,000					163,000
	4	along creek (same as B?)	3-4 bed houses	100			12			1200	1630	1,956,000					163,000
C	1	Flat block (above community space)	2 bed flats	70	12	2				840	1675	1,407,000	0	86,400	120,000	1,613,400	
	2	Flat block	2 bed flats	70	8	2				560	1675	938,000	100,000	72,000	120,000	1,230,000	
	3	infill blocks	2 bed flats	70	12	2				840	1675	1,407,000	100,000	72,000	120,000	1,699,000	
	4	infill blocks (ground floor)	4 bed maisonettes	100	5	1				500	1625	812,500	150,000	108,000	0	1,070,500	
	5	flats over	2 bed flats	70	16	2				1120	1675	1,876,000	125,000	90,000	120,000	2,211,000	
D		flats over residents social club	2 bed flats	70	28	6				1960	1725	3,381,000	0	198,000	360,000	3,939,000	
E	1	maisonettes along estate Northern edge	3 bed maissonettes	120		2		19	1	120	1675	201,000	42,500	30,600	120,000	521,400	
	2	flats over maisonettes along estate Northern edge	2 bed flats	85	38	2			2	76	1675	127,300	inc	inc			
F	1	Infill adjacent to and access to Type 1 flat blocks and roof extensions	flats mixed	80	80	5			5	400	1675	670,000	40,000	28,800	300,000	1,038,800	
	2	general infill (houses - to imitate existing)	3 bed 2 storey houses	110		3	110		3	330	1630	537,900	inc	inc	nil		179300
G	1	along creek	2 bed flats (10 blocks of 3)	70	30	3			3	210	1675	351,750	41,250	27,000	nil	420,000	
J	1	8 storey flats over civic space - in tower	1, 2, 3 bed flats/ maisonettes	70	70				17	1190	1675	1,993,250	nil	100,800	480000	2,574,050	

Estimates of costs by types

Flats

Type A

Foundations	GFA	448	m2	500.00	224,000	
Above ground works			m2	1600.00		
allowance for services & drainage connections				75.00	1,675	per m2
Roof		448	m2	360	161,280	

Type C1

5 storey flats -above community space

Above Ground works - as above					1,675	per m2
Roof - allow as 3 flats/floor + circulation		240	m2	360	86,400	

Type C2

3 storey flats

Foundations	GFA	200	m2	500.00	100,000	
Above Ground works - as above					1,675	per m2
Roof - allow as 3 flats/floor + circulation		200	m2	360	72,000	

Type C3

4 storey 2bed flats

Foundations	GFA	200	m2	500.00	100,000	
Above Ground works - as above			m2	1550		
allowance for services & drainage connections				75	1,625	per m2
Roof		200	m2	360	72,000	

Type C4

Infill block at ground floor

Foundations	GFA	300	m2	500.00	150,000	
Above Ground works - as above					1,675	per m2
Roof - allow as 3 flats/floor + circulation		300	m2	360	108,000	

Type C5

2 bed flats, 1 x 5 storey block

Foundations	GFA	250	m2	500.00	125,000	
Above Ground works - as above					1,675	per m2
Roof - allow as 3 flats/floor + circulation		250	m2	360	90,000	

Type D

Flats over social club - 7 flats/floor x 5 stories total

Above Ground works - as above			m2	1650		
				75	1,725	per m2
Roof - allow as 7 flats/floor + circulation		550	m2	360	198,000	

Type E

Maisonettes with 2 x 2bed flats over

Foundations	GFA	85	m2	500.00	42,500	
Above Ground works - as above					1,675	per m2
Roof - allow as 3 flats/floor + circulation		85	m2	360	30,600	

Type F1

2 bed flats, 1 x 5 storey block

Foundations	GFA	80	m2	500.00	40,000	
Above Ground works - as above					1,675	per m2
Roof - allow as 3 flats/floor + circulation		80	m2	360	28,800	

Type G1

2 bed flats, 3 stories x 10 blocks

Foundations	GFA	75	m2	500.00		
allow for piled foundations				50.00		
				550.00	41,250	
Above Ground works - as above					1,675	per m2
Roof - allow as 3 flats/floor + circulation		75	m2	360	27,000	

Type J1

Flats, 8 stories x 4 per floor. Built over new communal facility

Above ground works as above					1,675	m2
Roof		280	m2	360	100,800	

Lifts

Lifts allowed at £ 30,000 per floor/lift

Houses

Type B 1, 2, 3 & 4

2 storey 3 bed houses	GIFA	88	m2			
	As ASH costs			1504		
	add piled founds			50		
	services & drainage connections etc			76	1630	per m2

St Raphaels Estate, Neasden

Cost Estimates for New Build Roof Extension Units

Type		Description	Housing Types	M2 per unit	flats	houses	maisonettes	No off	GIFA	Rate/m2	Structure	
Proposed Roof Extensions												
H	1	Roof extensions on type 1	2 bed maisonettes	83			83	144	11952	1750	20,916,000	180
	2	Roof extensions on type 2 (above shops)	2 bed maisonettes	83			83	6	498	1750	871,500	180
	3	Roof extensions on type 5	1 bed flats	50	50			28	1400	1750	2,450,000	360
J	2	2 story maisonettes over civic space	2 bed maisonettes	83			83	3	249	1750	435,750	180

Estimates of Costs by types

Roof extension to maisonettes, 2 storey

Structure	rate per m2 GIFA	1750	m2
Roof structure & covering	rate per m2 roof (GIFA/2) 360 m2	180	
		1930	m2

Roof extension to flats; 1 storey	Structure	1750	m2
Roof structure & covering		360	
		2110	m2

St Raphaels Estate, Neasden

Cost Estimates for Refurbishment to Existing Dwellings

Description	flats	maisonettes	flat/ maisonette total	houses	total no	Cost per unit	Total
2-3 bed maisonettes		288					
1 bed flats over shops	18						
3 bed townhouses				180			
4 bed ? townhouses				60			
3 bed? Bungalows				6			
flats (1 bed?)	168						
flats (1 bed?)	21						
unknown (not included - Network homes)	19						
	207	**288**	495	**246**	**741**	39,000	**£28,899,000**

Allowance for refurbishments includes:-

Insulation to external walls; render on insulation
Insulation to roof voids
Replacement double glazed windows & doors

St Raphaels Estate, Neasden

	Cost Estimates for External Works					**Allowance**		**Total**
	Landscaping Works							
L1	Pedestrian priority paved areas	26000	m2			120	m2	3,120,000
L2	New Public Square	750	m2			130	m2	97,500
L3	Landscape rebuilding & remediation							300,000
L4	Pedestrian cut through access							15,000
L5	Play Spaces - new & relocated	2000	m2			150	m2	300,000
L6	Improved access to River							200,000
L7	Improved open green parks	86,350	m2			25	m2	2,158,750
	Allowance for planting incl. trees							500,000
	Allowance for phytoremediation							750,000
	Drainage							
	Surface water - including interceptors & filter beds							1,000,000
	Foul water - including sewer connections							1,500,000
	Sundry buildings							
	Bin stores - upgrade & replacement	300	no			8,000		2,400,000
	Bike sheds	360	no			6,500		2,340,000
	Balconies to new & existing buildings allowed as flats x 50%	402	no			5,000	each	2,010,000
	Total							£16,691,250

Cost Estimates for New Build and Refurbished Community Facilities

Type	Description	Description	Total
M1	New civic space	Ground floor space	740,000
M2	New civic space	Ground floor space	444,000
M3	Residents social centre	Ground floor space	1,399,500
M4	Refurbished shops		540,000
	Total		**£3,123,500**

M1	**New Civic Space**					
	Foundations	GFA	250	m2	500.00	125,000
	Above ground works		250	m2	2100.00	525,000
	Roof		250	m2	360.00	90,000
						740,000
M2	**New civic space**					
	Foundations	GFA	150	m2	500.00	75,000
	Above ground works		150	m2	2100.00	315,000
	Roof		150	m2	360.00	54,000
						444,000
M3	**New Residents Social Centre**					
	Foundations	GFA	450	m2	500.00	225,000
	Above ground works		450	m2	2250.00	1,012,500
	Roof		450	m2	360.00	162,000
						1,399,500
M4	**Refurbished shop units**					
	Refurbished retail units inc new services etc excluding fit-out		400	m2	1350.00	540,000
						540,000

B. Embodied Carbon Assessment by Model Environments

St Raphael's Estate, London, NW10 0BH
Embodied Carbon Assessment

Rev:	C
Date:	30th June 2021

Contents

SCOPE

Model Environments were appointed by Architects for Social Housing (ASH) to estimate the Embodied Carbon (EC) of the existing residential buildings comprising the St Raphael's Estate in Brent, London, and to estimate the EC associated with options to redevelop the site.

Embodied Carbon was assessed with reference to:

1. Royal Institute of Chartered Surveyors (RICS) document *"Whole life carbon assessment for the built environment"* (November 2017).
2. Royal Institute of British Architects document *"RIBA 2030 Climate Challenge"* (2019).
3. The *"Inventory of Carbon and Energy (ICE)"* database (November 2019) authored by Dr. Craig Jones and Professor Geoffrey Hammond. A link to the latest version of ICE is here:

http://www.circularecology.com/embodied-energy-and-carbon-footprint-database.html

4. The Institution of Structural Engineers publication *"How to Calculate Embodied Carbon"* (CEC) (August 2020).

In the absence of detailed information regarding existing and proposed construction materials and building design, a full Whole-Life-Carbon-Assessment has not been attempted. Rather a best estimate of EC has been arrived at using information provided by ASH, contained in the sources above, and from sources referenced in the report below. The scope and limitations of the analysis, including where necessary any assumptions, are made explicit throughout the text.

EXECUTIVE SUMMARY

To completely demolish and redevelop St Raphael's Estate would incur a significant carbon cost, far greater than that of refurbishing the existing buildings and adding new infill housing.

It is estimated that the carbon cost of each new home in a scheme to demolish and redevelop would be around four times that of each home in a scheme to refurbish and infill.

The total Embodied Carbon (EC) cost of demolition plus redevelopment was estimated at approximately 100,000 Tonnes of CO_2; this figure represents both the loss of EC from existing buildings (whose life could be extended), and an EC cost due to redevelopment.

It is our opinion that for this site, due to the scale of the EC cost of demolition/redevelopment, and the potential for improvements to the existing buildings energy performance through refurbishment, that the 'break even time' due to higher expected energy performance of new development homes, compared to that of existing homes, would fall far outside any reasonable (60 year) lifespan of the new buildings.

METHODOLOGY

The RICS document *"Whole life carbon assessment for the built environment"* sets out the carbon emissions associated with the different life cycle stages of a building; from extraction, processing, and transport of building materials; to construction; operational use; and end of life demolition and recycling. The table below from page 12 of the RICS guidance summarises the life cycle stages of a building.

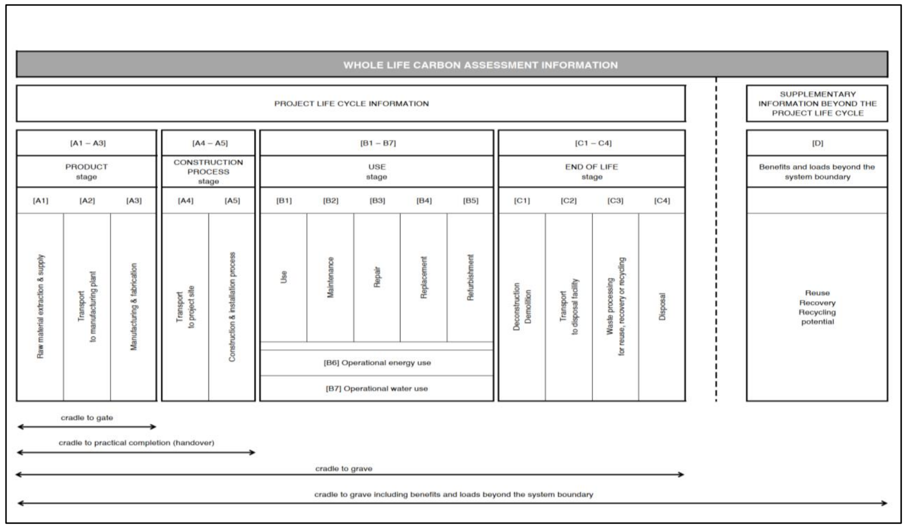


Figure 1: RICS - Life cycle stages of a building

The RIBA document *"RIBA 2030 Climate Challenge"* gives EC benchmarks and targets for buildings covering the stages A1 to C4, or 'cradle to grave' from the RICS document above. The EC benchmarks exclude stages B6 and B7 covering operational energy and water use, which are covered separately. The table below, from page 3 of the RIBA document shows these EC target values.

RIBA 2030 Climate Challenge target metrics for domestic buildings

RIBA Sustainable Outcome Metrics	Current Benchmarks	2020 Targets	2025 Targets	2030 Targets	Notes
Operational Energy kWh/m²/y	146 kWh/m² /y (Ofgem benchmark)	< 105 kWh/m²/y	< 70 kWh/m²/y	< 0 to 35 kWh/m²/y	UKGBC Net Zero Framework 1. Fabric First 2. Efficient services, and low-carbon heat 3. Maximise onsite renewables 4. Minimum offsetting using UK schemes (CCC)
Embodied Carbon $kgCO_2e/m^2$	1000 $kgCO_2e/m^2$ (M4i benchmark)	< 600 $kgCO_2e/m^2$	< 450 $kgCO_2e/m^2$	< 300 $kgCO_2e/m^2$	RICS Whole Life Carbon (A-C) 1. Whole Life Carbon Analysis 2. Using circular economy Strategies 3. Minimum offsetting using UK schemes (CCC)
Potable Water Use Litres/person/day	125 l/p/day (Building Regulations England and Wales)	< 110 l/p/day	< 95 l/p/day	< 75 l/p/day	CIBSE Guide G

Figure 2: RIBA Embodied Carbon targets

Using the RIBA targets above enables a simplified methodology for estimating EC using a buildings total floor area.

An estimate of the principal EC costs due to refurbishment of the existing buildings, was made with reference to EC values for insulation and glazing materials found in the ICE database, and by using Embodied Carbon Factors (ECF) contained in The Institution of Structural Engineers publication, CEC.

RESULTS

1. Existing Residential Buildings

St Raphael's Estate comprises several different residential property types ranging from 1-bed flats to 3/4 bed townhouses, spread across buildings varying in height from one to four storeys. There are a total of 760 existing homes.

It was assumed that the existing St Raphael's buildings, completed approximately 40 to 50 years ago, achieve at a minimum an EC benchmark of 1,000kgCO_2/m^2.

The total internal floor area across all existing residential units was estimated at 57,669m^2.

Using the RIBA current EC benchmark, the total 'cradle to grave' EC across all existing St Raphael's residential buildings was calculated:

EC_{Total} = 57,669 x 1,000 = 57,669,000kgCO_2

EC_{Total} = 57,669 TonnesCO_2

2. Architects for Social Housing (ASH) Infill Proposal

ASH propose infilling various areas of St Raphael's Estate with new residential buildings to create a total of 608 new homes, with a total proposed internal floor area of 48,999m^2.

Assuming that these new homes are built according to the higher low carbon standards suggested by the RIBA Climate Challenge 2030, estimates of the EC associated with this infill proposal were calculated, and the results appear in the table below.

RIBA Embodied Carbon Metric	Embodied Carbon *(Tonnes of CO_2)*
2020 Target: <600kgCO_2/m^2	29,399 TonnesCO_2
2025 Target: <450kgCO_2/m^2	22,049 TonnesCO_2
2030 Target: <300kgCO_2/m^2	14,700 TonnesCO_2

3. Refurbishment

A simplified estimate of the EC costs of refurbishment of the 760 existing homes was made by considering two of the principal aspects of refurbishment: installing upgraded insulation and replacing all the glazing with new units.

EC values in the ICE database were used to give estimates for the EC costs associated with stages A1 – A3 (cradle to factory gate).

Stage A4, the EC cost of transportation of building materials to the construction site, was evaluated using Embodied Carbon Factors (ECF) in the Institution of Structural Engineers publication, CEC.

Stage A5, the EC cost of construction, was evaluated using the simplified method recommended by RICs on p.19 of their guide; this uses a single value of EC per £100k of project value.

Stages B1 – B5 (usage, maintenance, repair, replacement, and refurbishment) were not considered. It may be noted that some of these factors would apply to glazing, but none are likely to apply to insulation fitted inside walls/floors. It may further be noted that B1 – B5 EC costs are likely to be very low compared to overall EC. The Institution of Structural Engineers says, on p.23, section 2.2.5.1 of the CEC:

"Modules B1 -B5 together are likely to account for a very small and sometimes negligible percentage of structural EC over the lifecycle".

Stages B6 and B7 (operational energy and water use) are not applicable to insulation and glazing.

Stages C1 – C4 (end of life) were not considered. It may be noted that CEC states on p.24, section 2.2.5.2 that:

"Modules C1 – C4 are likely to account for a small percentage of structural EC over the lifecycle..."

Hence the EC costs of refurbishment were evaluated for stages A1 – A5; cradle to practical completion of refurbishment works.

a) Insulation

It was assumed that 100mm insulation boards were fitted across the total floor, wall, and roof areas of all homes.

The wall area was estimated by calculating the average internal floor area of each residential unit and assuming wall insulation was installed in all the walls (internal and external) bounding each unit, therefore not fitting insulation to internal walls within each unit. Wall height was taken as 2800mm throughout.

It was assumed that on average the existing buildings are 3-storeys with a flat roof above the 2nd floor; hence the roof area to insulate is one-third of the total internal floor area across the whole estate.

The total area of walls, floors and roof was estimated at: 152,892m^2.

100mm insulation board has an approximate weight per area of: 3kg/m^2.

The ICE database gives an EC figure for general insulation of: 1.86kgCO_2e/kg.

So, the EC cost of insulation for stages A1 – A3 was calculated:

$$EC_{A1\text{-}A3}\ (\text{insulation}) = 152{,}892 \times 3 \times 1.86 = 853{,}137\text{kg}CO_2$$

b) Glazing

It was assumed, for the existing homes, that the ratio of glazed area to floor area was 20%. This is a typical value, for example, The Building Regulations, Part L1A (2013), states on p.16:

"As a general guide, if the area of glazing is much less than 20% of the total floor area, some parts of the dwelling may experience poor levels of daylight..."

Therefore, the total glazed area was estimated at: 11,534m^2.

The glass was assumed to be double glazing with 12mm glass thickness.

The ICE database gives an EC value of 48.8kgCO_2e/m^2 for this material.

So, the EC cost of glazing for stages A1 – A3 was calculated:

$$EC_{A1\text{-}A3}\text{ (glazing)} = 11{,}534 \times 48.8 = 562{,}859\text{kg}CO_2$$

c) Glazing Frames

It was assumed that replacement windows have aluminium frames with a typical weight per metre of 0.7kg/m (see for example http://www.alomextrusions.com/om.pdf p.31-35).

The ICE database gives an EC value of 6.83kgCO_2e/kg for European extruded aluminium profile.

It was assumed that the glazing units come in 1m x 1m units. Hence the length of aluminium extrusion used in the window frames is 4× the window area.

So, the EC cost of glazing frames for stages A1 – A3 was calculated:

$$EC_{A1\text{-}A3}\text{ (frames)} = (11{,}534 \times 4) \times 0.7 \times 6.83 = 220{,}571\text{kg}CO_2$$

d) Stage A4 – EC Costs of Transportation

The Institution of Structural Engineers publication CEC gives default Embodied Carbon Factors (ECF) in table 5 on p.19. These ECF's apply to the transport of building materials either locally, nationally, or internationally.

It was assumed that new glazing units and insulation boards required for refurbishment works could be sourced from a national manufacturer, in the UK. Hence, the national ECF value was chosen: 0.032kgCO_2e/kg.

The total weight of refurbishment materials was estimated at: 836,991kg.

So, the EC cost of transportation was calculated:

$$EC_{A4} = 836{,}991 \times 0.0032 = 26{,}784\text{kg}CO_2$$

e) Stage A5 – EC Costs of Construction

The cost of refurbishing each existing home was estimated at £20,000.

The RICs document recommends using an EC value of 1400kgCO_2/£100,000 of project value.

So, the EC costs of construction were calculated:

$$EC_{A5} = 1400 \times (20{,}000 \times 760) / 100{,}000 = 212{,}800\text{kg}CO_2$$

f) Total A1 – A5 EC Cost of Refurbishment

The cradle to practical completion of works EC cost of refurbishment was calculated by adding the A1 – A3, A4, and A5 EC costs:

$$EC_{A1\text{-}A5} = 1{,}876{,}151\text{kg}CO_2 = 1{,}876\text{Tonnes}CO_2$$

4. Proposal to Demolish and Redevelop St Raphael's Estate

Karakusevic Carson Architects (KCA) were appointed by Brent Council to design redevelopment options for St Raphael's Estate, and several proposals for complete demolition and redevelopment were presented at a public exhibition in March 2020. The options presented by KCA all comprise the building of approximately 2000 new residential homes of different sizes.

An estimate was made of the average floor area of the proposed units via comparison with the existing homes on the estate. It was estimated that a redevelopment proposal comprising 2000 homes has a total floor area of 151,760m^2

Estimates of the EC associated with this redevelopment were calculated, and the results appear in the table below.

RIBA Embodied Carbon Metric	**Embodied Carbon *(Tonnes of CO_2)***
2020 Target: <600kgCO_2/m^2	91,056 TonnesCO_2
2025 Target: <450kgCO_2/m^2	68,292 TonnesCO_2
2030 Target: <300kgCO_2/m^2	45,528 TonnesCO_2

CONCLUSION

To demolish the existing residential buildings comprising St Raphael's Estate, replacing them with new residential buildings, would incur a significant carbon cost, both in terms of what was lost, and what was built.

At best, using the ambitious RIBA 2030 EC target, a demolition and complete redevelopment of the site into approximately 2000 new homes, could hope to incur an EC cost of around 100,000 Tonnes of CO_2, when taking into account the EC cost from the loss of the existing site with that of the EC cost of the new construction.

To infill the site with around 600 new homes and refurbish existing homes would also incur an EC cost. If the most stringent RIBA 2030 target is used for the infill buildings, the cost of infill plus refurbishment would be approximately 17,000 Tonnes of CO_2 or 17% that of the EC cost of demolition/redevelopment.

Moreover, the infill/refurbishment proposal provides approximately 70% of the total number of homes proposed by demolition/redevelopment, which is a disproportionately large number compared with the discrepancy in EC cost. This discrepancy translates into making the EC cost of each infill proposal home (including the existing homes) approximately four times lower than that for each home proposed under demolition/redevelopment of the whole site.

Operational energy use (stages B6 and B7 highlighted in the RICs guidance) is another factor to be considered when comparing the environmental cost of buildings. It can be assumed that the operational energy use of new buildings will outperform that of the existing (decades old) buildings.

The 'break-even' time is used to define at what point in the future the increased EC costs associated with new buildings, where they replace old ones, are cancelled out by improved energy performance. If the 'break-even' time falls within the estimated lifespan of the new building (sometimes taken as 60 years), then it may be that the proposal is considered favourable in terms of its overall environmental cost.

It is notoriously difficult to make direct accurate comparisons between energy use values and EC values. The carbon intensity of the National Grid is constantly changing due to the increase in renewable energy sources, whereas the carbon cost of each fossil fuel source used, for example, for heating, remains roughly constant over time. In the last five years the National Grid EC cost per kilowatt hour (kWh) has fallen from around 500kgCO_2 per kWh, to around 150kgCO_2 per kWh. In addition to this changing picture of energy carbon costs, each site and building are different and specific heating plans may be used to contrast the operational energy use profiles between them.

Nevertheless, despite the absence of information required to complete a detailed study, in the context of St Raphael's Estate, it is the opinion of this author that refurbishing the existing buildings with the aim of reducing their energy use as far as practically possible, coupled with the large EC cost of demolition/redevelopment, would result in a break-even time far outside any anticipated lifespan for a new building. If correct, this assertion implies that the EC cost outlined in this report may be regarded as a real and significant environmental cost inherent in demolition and redevelopment of St Raphael's Estate.

Issue	Date	Remarks	Prepared	Checked
A	25th March 2021	draft	HW	
B	2nd April 2021		HW	
C	30th June 2021		HW	

C. Phytoremediation by Down to Earth

Phytoremediation

A working summary produced for Architects for Social Housing
and for residents of the St Raphael's Estate, London.
Adriana Massidda, Leicester School of Architecture - May 2020/March 2021

Phytoremediation is one of the techniques currently used to remove contaminants from soil and water with the purpose of mitigating or avoiding negative effects in the human body ('phyto'=plant; 'remediation' refers to this removal process). At its most basic, it displaces mineral elements into the plant's tissues, and also engages the plants' associated microbia in chemical processes related to the contaminants.

Advantages:

- creates enjoyable outdoor space, enhancing users' wellbeing
- nature-based solution (as such it does not add to the carbon footprint)
- low-cost (it only involves sourcing, planting and maintaining the plants, which use solar energy, as opposed to energy-heavy techniques such as soil removal)

Drawbacks:

- slow (in water may take months; in soil, years)
- limited effectivity (it may mitigate yet not fully remove the contaminants)
- in most cases, it does not neutralize the contaminant at the molecular level, but simply displaces it to the plant's tissues. Thus, one is left with a contaminated plant to dispose of safely, which may be expensive or difficult to implement
- moreover, concentrating contaminants in an element with which residents can have physical contact, may increase risks rather than mitigating them

Other comments:

- root-length removal (average 50cm; it varies according to species and climates; there exist additional techniques to increase it exist)
- sometimes the most effective plant species to remove a contaminant is considered invasive in a specific area/environment/climate (for example the water hyacyntus in the UK)

Research on phytoremediation advances at a fast pace, and has been doing so for over twenty years. An indicative reference list can be found at the bottom of this document, although that shouldn't be considered representative – in reality, the bibliography is immense. Interested readers will want to do their own research.

Phytoremediation is only one of the existing soil remediation techniques. Another system, and one of the most used, is **soil excavation**, often preferred for being fast and effective. It consists of the removal of an upper layer of soil of variable depth using construction machinery. It presents the challenge of being left with hazardous waste (the removed soil) to treat and dispose of. At St Raphael's, the Brent Council has used a **cover system**, which consists of the installation of a geomembrane and the laying of clean soil on top of it.[1] This is a cost- and time-effective method but with limited results in the longer run. It is also slightly invasive in the sense that it creates new waste/introduces the presence of a human-made feature in the soil, which should be arguably avoided. Some further techniques are **bioremediation**, where bacteria are able to break-up the contaminants at the molecular level, and **mycoremediation**, which uses fungi.

Indicative reference list

Aweng, E., Muhammad Irfan, A., Liyana, A.A., Sharifah Aisyah, S., 2018. 'Potential of phytoremediation using Scirpus validus for domestic waste open dumping leachate.' *Journal of Applied Sciences and Environmental Management* 22, 74–78.

Ehrl, B., Gharasoo, M., Elsner, M., 2018. 'Isotope Fractionation Pinpoints Membrane Permeability as a Barrier to Atrazine Biodegradation in Gram-negative Polaromonas sp. Nea C.' Environmental Science and Technology 52, 4137–4144.

Jones, J.L., Jenkins, R.O., Haris, P.I., 2018. 'Extending the geographic reach of the water hyacinth plant in removal of heavy metals from a temperate Northern Hemisphere river.' *Scientific Reports* 8.

Kundu, K., Marozava, S., Ehrl, B., Merl-Pham, J., Griebler, C., Elsner, M., 2019. 'Defining lower limits of biodegradation: atrazine degradation regulated by mass transfer and maintenance demand in Arthrobacter aurescens TC1.' The ISME Journal 13, 2236–2251.

Kuppusamy, S., Thavamani, P., Venkateswarlu, K., Lee, Y.B., Naidu, R., Megharaj, M., 2017. 'Remediation approaches for polycyclic aromatic hydrocarbons (PAHs)

[1] Brent Council. 'REMEDIATION STATEMENT'; Vertase FLI, 'Part 2a Remediation West London'.

contaminated soils: Technological constraints, emerging trends and future directions.’ *Chemosphere* 168, 944–968.

Pilon-Smits, E., 2005. ‘Phytoremediation.’ *Annual Review of Plant Biology* 56, 15–39.

Zhu, L., Lu, L., Zhang, D., 2010. ‘Mitigation and remediation technologies for organic contaminated soils.’ *Frontiers of Environmental Science & Engineering* 4, 373–386.

Phytoremediation within St Raphael’s?

Phytoremediation is most effective in dealing with minerals, as plants mainly absorb inorganic matter. For St Raphael’s Estate, the few existing reports (see list at the end) indicate presence of PAHs, which are, in contrast, organic components. For components of this type, some studies suggest that they could still be mitigated through the use of specific plants, specifically through phytostimulation: here, the plants utilized would promote the growth of microbia in the upper layer of the soil, which would in turn degrade the PAHs.[2] Other studies, however, indicate that the capacity of micro-organisms in synthesising organic components requires further research.[3]

For outlining a landscape design approach for St Raphael’s, we have taken the working assumption that it is worth looking at phytoremediation in our proposed scheme. Even if effectivity is low, the assumption is that plants could help as a low-cost, un-invasive way of gradually mitigating traces of contaminants left, if any. Having said this, no recent studies have, to the best of our knowledge, been undertaken at this stage, and the actual situation and needs at St Raphael’s must be studied through a thorough process of sampling, analysis and consultation.

Following reviews such as Pilon-Smits, it seems that the plants most effective for removing PAHs are different types of grass, preferred for the density of their roots.[4] They can be used as part of a landscape proposal with different sectors and atmospheres according to the grasses used. For St Raphael’s we looked at fescue (Festuca sp.) and ryegrass (Lolium sp.) specifically as two species native to the UK.

[2] Pilon-Smits, ‘Phytoremediation,’ p. 19 and throughout. See also the studies reviewed by her in this piece.
[3] Kundu et al., ‘Defining lower limits of biodegradation’; Ehrl et al, ‘Isotope Fractionation Pinpoints…’.
[4] Pilon-Smits, ‘Phytoremediation’.

fescue (*Festuca sp.*)
Native to the UK

Image credits:
Jean_Claude, wikimedia commons
Peggy A. Lopipero-Langmo@flickr

ryegrass (*Lolium sp.*)
Native to the UK

Image credits:
Hans@Pixabay
Matt Lavin@flickr

Relevant reports on St Raphael’s Estate

Brent Council. ‘REMEDIATION STATEMENT. Land at St Raphael's and Brentfield Estates’. April 2011. Available at https://www.brent.gov.uk/media/16409004/brent-council-contaminated-land-register.pdf [last accessed 18th March 2021].

Brent Council. ‘Summary of Contaminated Land Investigation and Remediation: St Raphael’s and Brentfield Estates.’ London, April 2011. 5 pages.

Rick Mather Architects. ‘LAND CONTAMINATION. Section 1: RPS Desk Study. Section 2: Brent Dury Way Depot - Phase 1 Desk Study.’ Originally produced by RPS Planning Transport and Environment. London, 2010. Available at the Brent Planning Portal [last accessed 2nd April 2020].

Taylor, Christopher. ‘Phase 1 Desk Study. Drury Way Depot’. London: Brent Council: Environmental Health, September 2008. Available at the Brent Planning Portal [last accessed 2nd April 2020].

St Raphael's Estate, London – Environmental History

Adriana Massidda - May 2020/March 2021

This is a working document produced for Architects for Social Housing and for residents of the St Raphael's Estate. It reflects my current understanding of the environmental history of the estate as part of the ongoing research project 'Down to Earth: Contamination and Collective Design in Contexts of Urban Poverty', in the context of the debate regarding the estate's redevelopment. These are initial reflections to stimulate conversation among colleagues and residents, and the document is by no means intended to be an in-depth report.

Information about the environmental history of St Raphael's Estate is extremely scarce. The summary below condenses the following documents:

- Historic Ordnance maps, 1870s to 1970s: see illustrations at the end.

Phase 1 studies (2005 and 2008):[1]

- Rick Mather Architects. 'LAND CONTAMINATION. Section 1: RPS Desk Study. Section 2: Brent Dury [Sic] Way Depot - Phase 1 Desk Study.' Originally produced by RPS Planning Transport and Environment. London, 2010. Available at the Brent Planning Portal (file Land_contamination-2592072.tif) [last accessed 2nd April 2020].
- Taylor, Christopher. 'Phase 1 Desk Study. Drury Way Depot'. London: Brent Council: Environmental Health, September 2008. Available at the Brent Planning Portal (file Phase_1_desk_study-1091736.tif) [last accessed 2nd April 2020].

Phase 2 study and intervention (2011):

- Brent Council. 'REMEDIATION STATEMENT. Land at St Raphael's and Brentfield Estates'. April 2011. Available at https://www.brent.gov.uk/media/16409004/brent-council-contaminated-land-register.pdf [last accessed 18th March 2021].
- Brent Council. 'Summary of Contaminated Land Investigation and Remediation: St Raphael's and Brentfield Estates.' London, April 2011. 5 pages.[2]

Cover system applied (2011):

- Vertase FLI, 'Part 2a Remediation West London'. Available at http://www.vertasefli.co.uk/our-expertise/case-study/part-2a-remediation-west-london [last accessed 18th March 2021]

A 'Phase 1' or desk report is one produced from the specialist's desk, based on historical documents and third-party information, in contrast to a Phase 2 study which involves taking and analysing samples (soil, or others).

St Raphael's soil

The area where St Raphael's estate sits today contained a sewage farm during the period 1886-1911, and also a gravel pit which was later filled-in with unspecified material. These can be clearly seen in Ordnance maps (see A4 series, at the end of this document).

Desk studies (Phase 1) about the contamination of the area were done in 2005[3] and 2008[4] and a more thorough (Phase 2) study in 2011,[5] the latter over 1,200 households.

The studies found polycyclic aromatic hydrocarbons (PAH), which is a type of contaminant that, when concentrated, can affect human health.[6] Benzo(a)pyrene was used as a marker, but others could have been present too. They established a threshold for the presence of this substance to be considered harmful (17mg/kg), and based on that they singled out 5 main areas where this concentration existed. It is there that they applied the geomembrane described below.

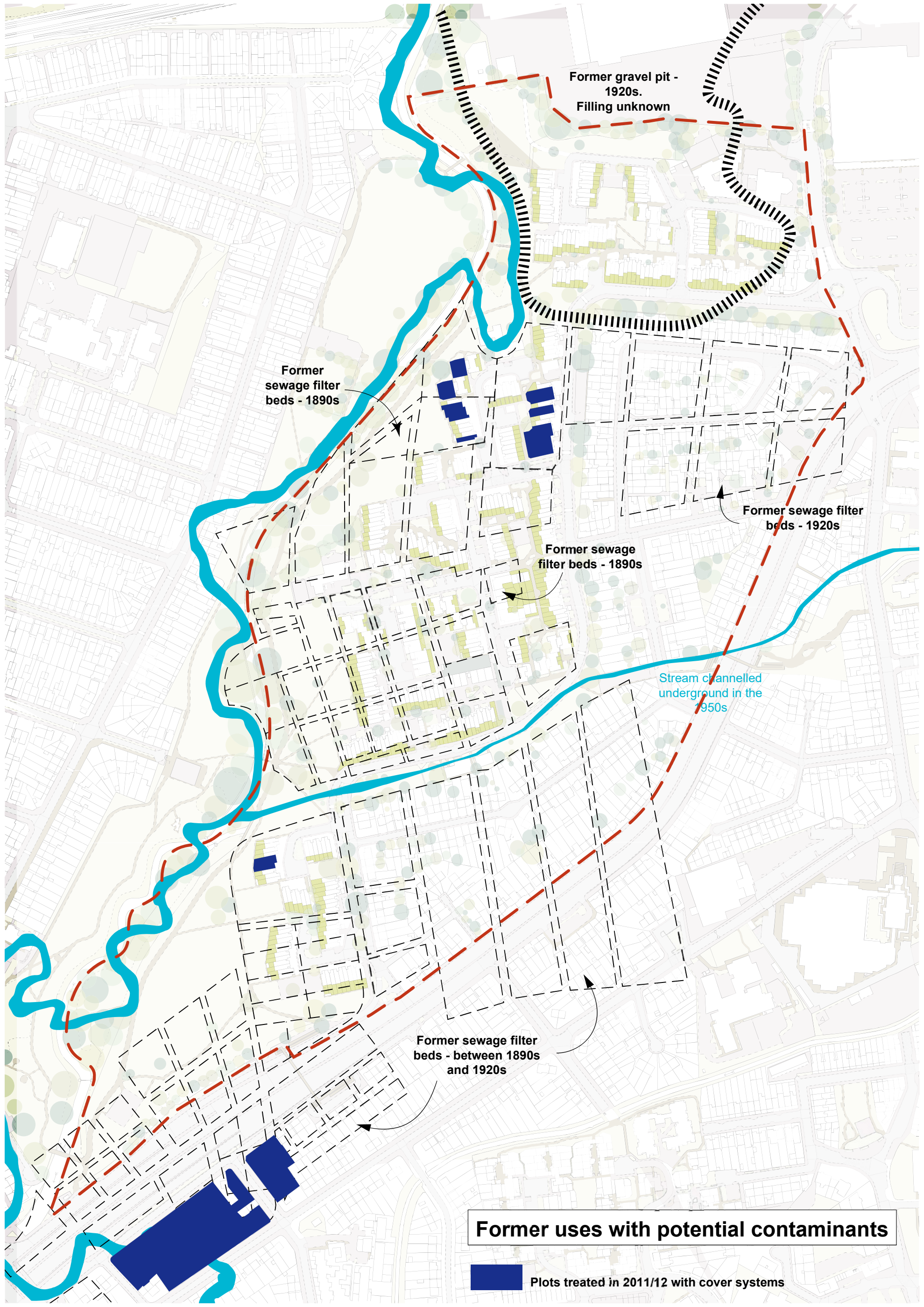
[1] Both Phase 1 reports are available at the Brent Council portal, planning application 10/1764, yet they are not straightforward to find:
https://pa.brent.gov.uk/online-applications/applicationDetails.do?activeTab=documents&keyVal=DCAPR_101481
Once in the page, go to 'View Documents' tab. The relevant entries are '03 Apr 2012 - Approved Documents - Phase 1 desk study', for Taylor's report, and '03 Apr 2012 - Approved Documents - Land contamination' for Rick Mather Architects'.
Please note that the facility for previewing documents in this portal does not work well. If you intend to view or download the document, make sure to select it by ticking the box to the left, and click 'Download Selected Files'. The relevant file names for each report are 'Phase_1_desk_study-1091736.tif' and 'Land_contamination-2592072.tif' respectively.
The reports are in tiff format. In a Windows platform, tiff files can be navigated page by page by using the Windows Photo Viewer and the arrows displayed at the bottom of the image.
Please note that the relevant report for the 2005 desk study was actually published in July 2010.

[2] This report is not publicly available and was obtained through direct consultation with the Council. 'REMEDIATION STATEMENT' does, however, contain a summary of its contents.

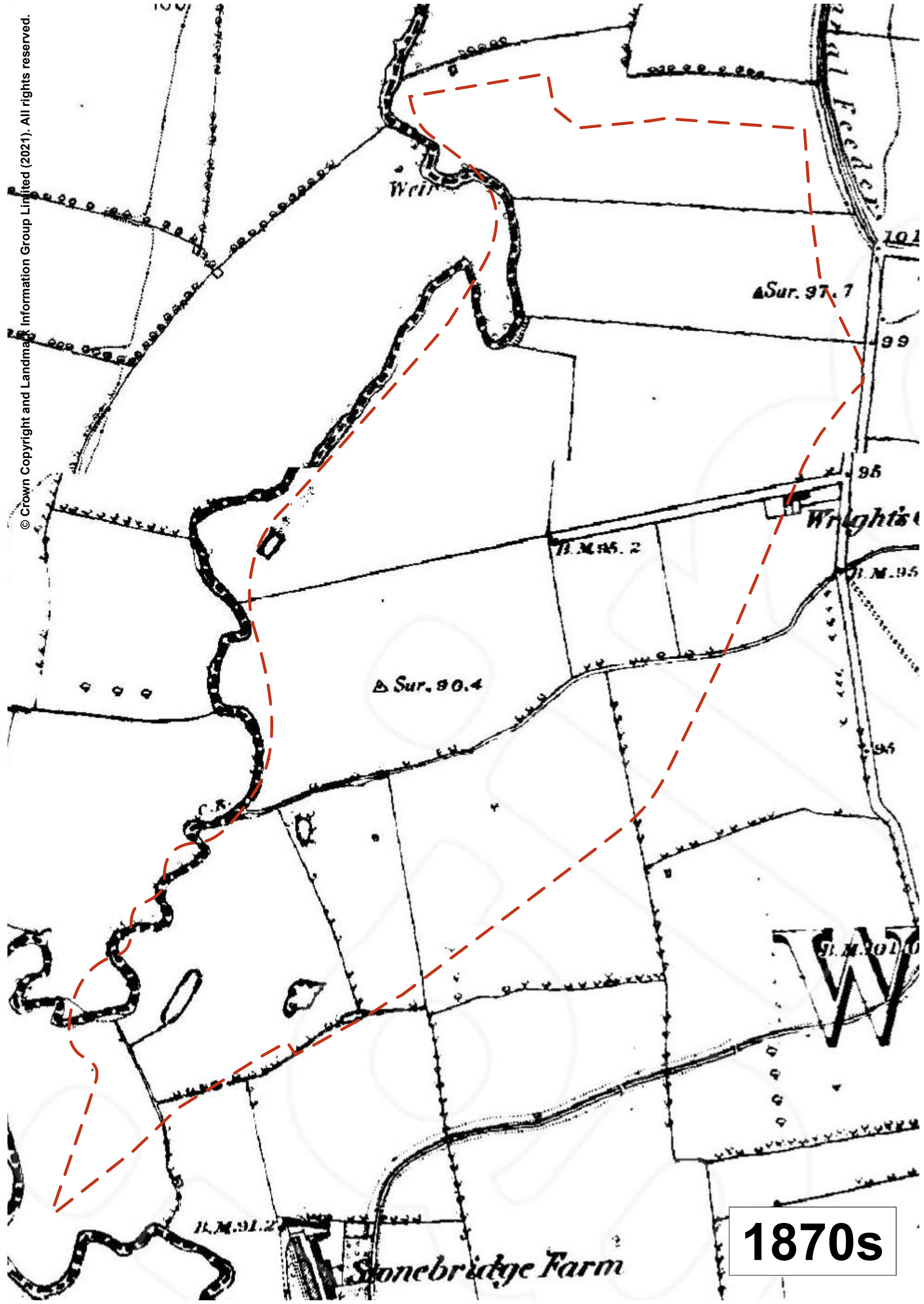
[3] Rick Mather Architects. 'LAND CONTAMINATION'.
[4] Taylor, 'Phase 1 Desk Study. Drury Way Depot'.
[5] Brent Council. 'Summary of Contaminated Land…'
[6] The presence of PAHs in London soil is not uncommon: see Vane, C.H., Kim, A.W., Beriro, D.J., Cave, M.R., Knights, K., Moss-Hayes, V., Nathanail, P.C., 2014. 'Polycyclic aromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCB) in urban soils of Greater London, UK.' *Applied Geochemistry* 51, 303–314.

As a system, the membrane does not remediate the soil but looks to break the 'pathway', this is to say, to ensure that the user has no contact with the contaminant. There is a total of 600mm of new soil on top of the membrane. In the plots with over 17mg/kg benzo(a)pyrene, the membrane was only used in soft landscape, so any soil under buildings and pavements would still be untreated. Based on the information available, common spaces do not seem to have been treated either, although the sources are not sufficient to state this conclusively. The mitigation works were funded with a £1.4m grant from the Department for Environment, Food and Rural Affairs / Environmental Agency (Defra/EA), national government.

Considerations about the traces of contaminants that might have been left in St Raphael's soil are important generally, but even more so in the case of building demolition. In other words, the cost and time delays derived from the investigation and mitigation of contamination in St Raphael's should be taken into account by the Brent City Council and clearly communicated to residents, especially with regards to the redevelopment option. An infill option would still have to investigate possible contaminants and their mitigation, but this would imply a smaller scale as soil underneath existing constructions would not be exposed.



Former gravel pit - 1920s. Filling unknown
Former sewage filter beds - 1890s
Former sewage filter beds - 1920s
Former sewage filter beds - 1890s
Stream channelled underground in the 1950s
Former sewage filter beds - between 1890s and 1920s
Former uses with potential contaminants
Plots treated in 2011/12 with cover systems



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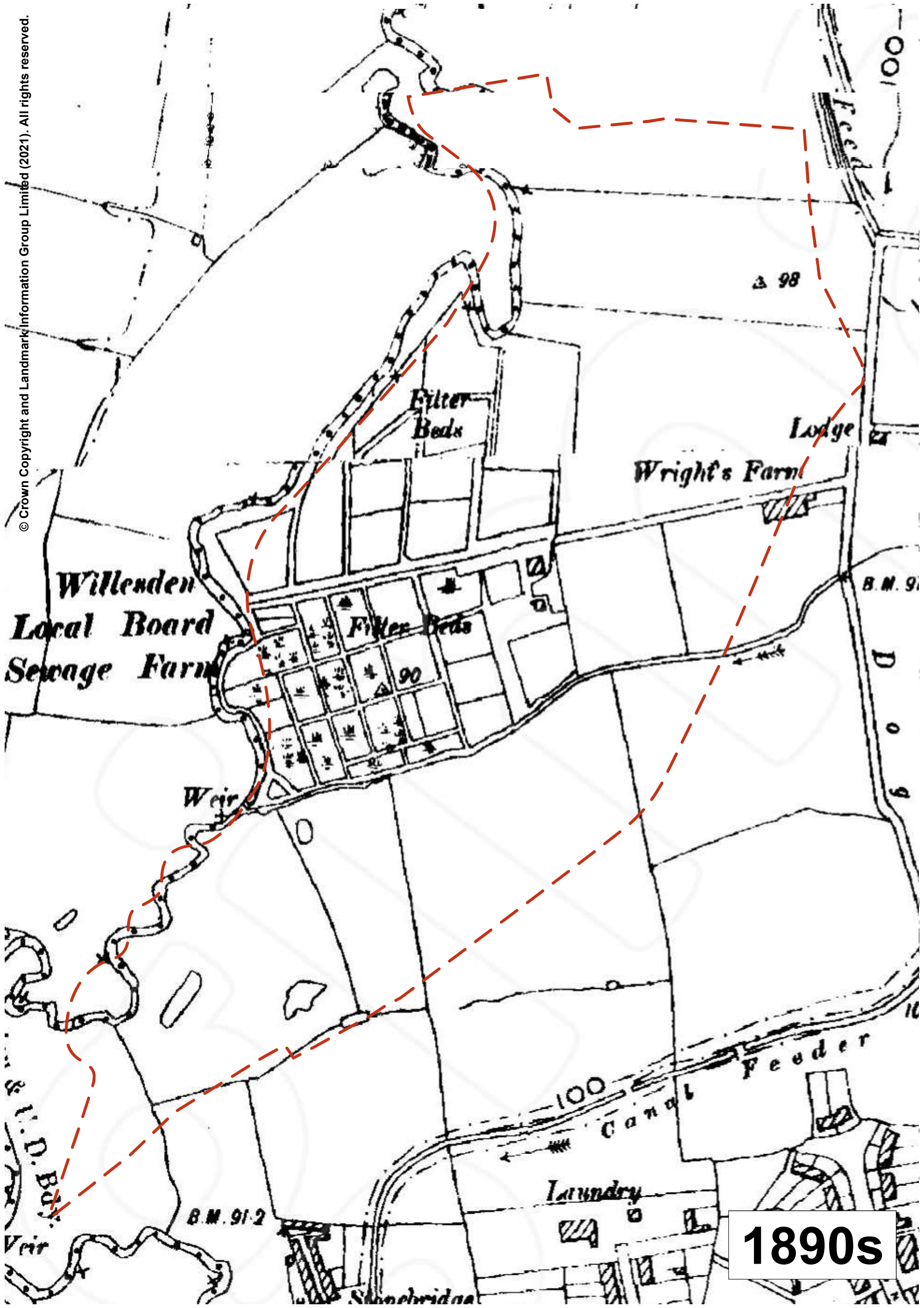
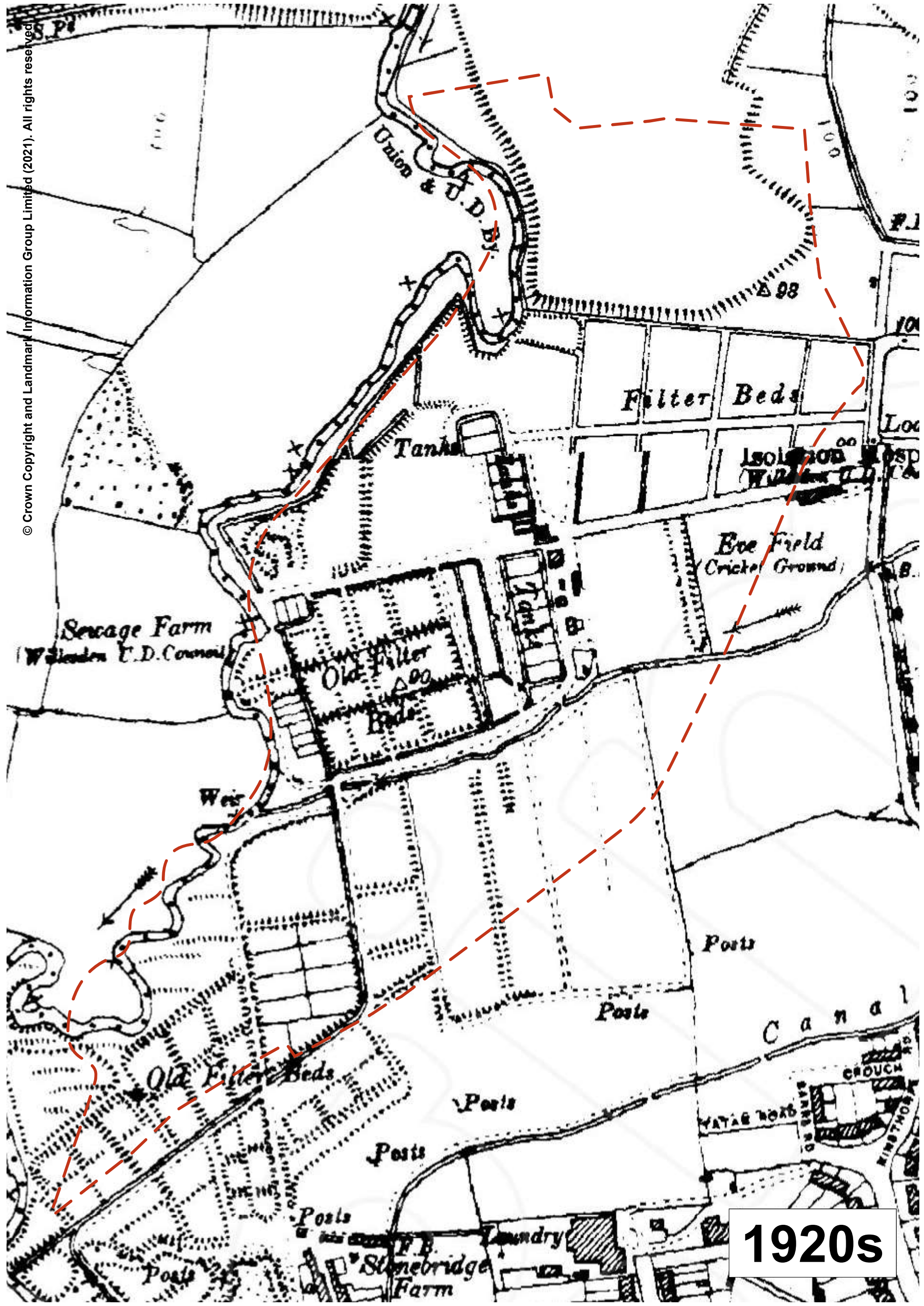
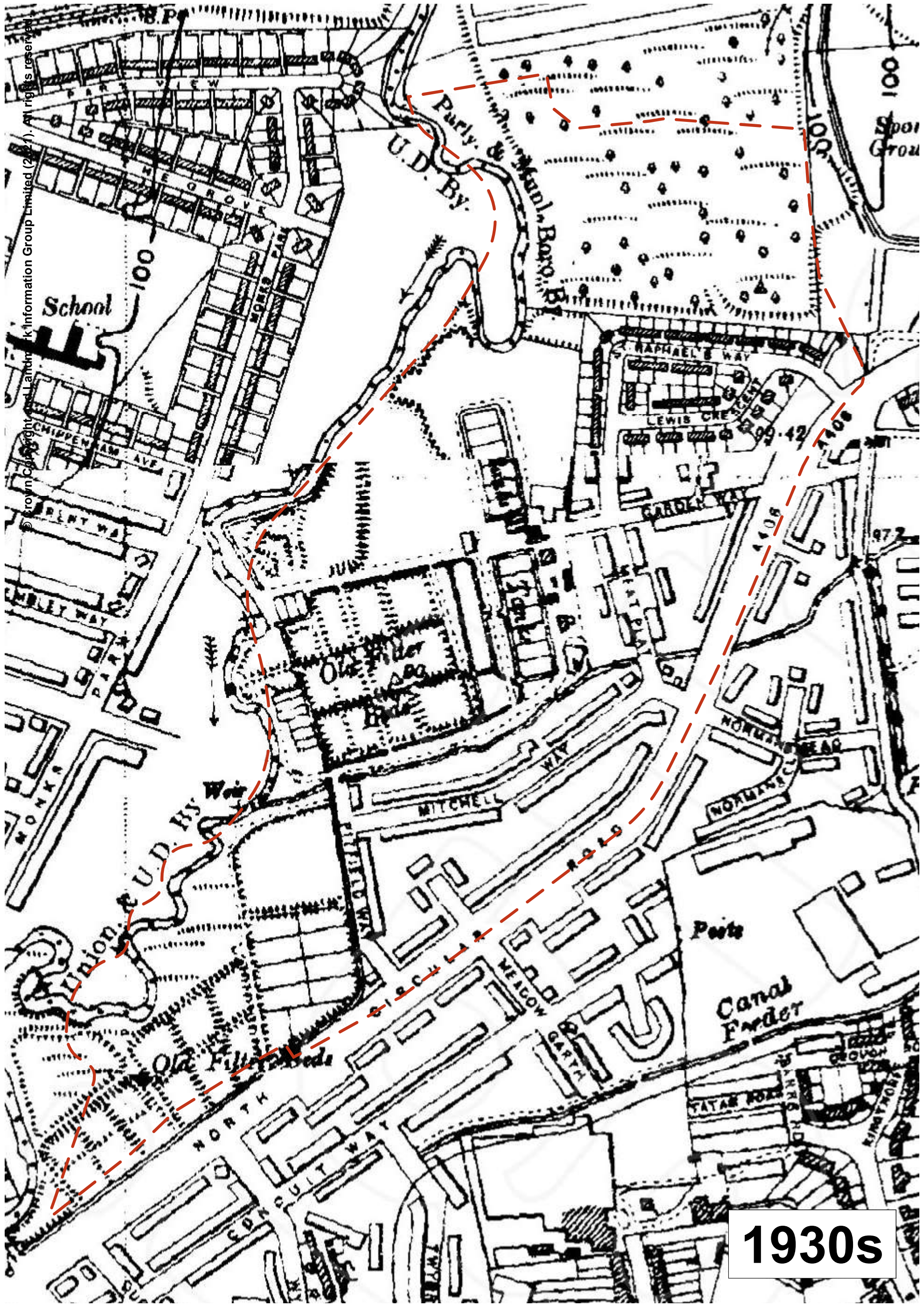
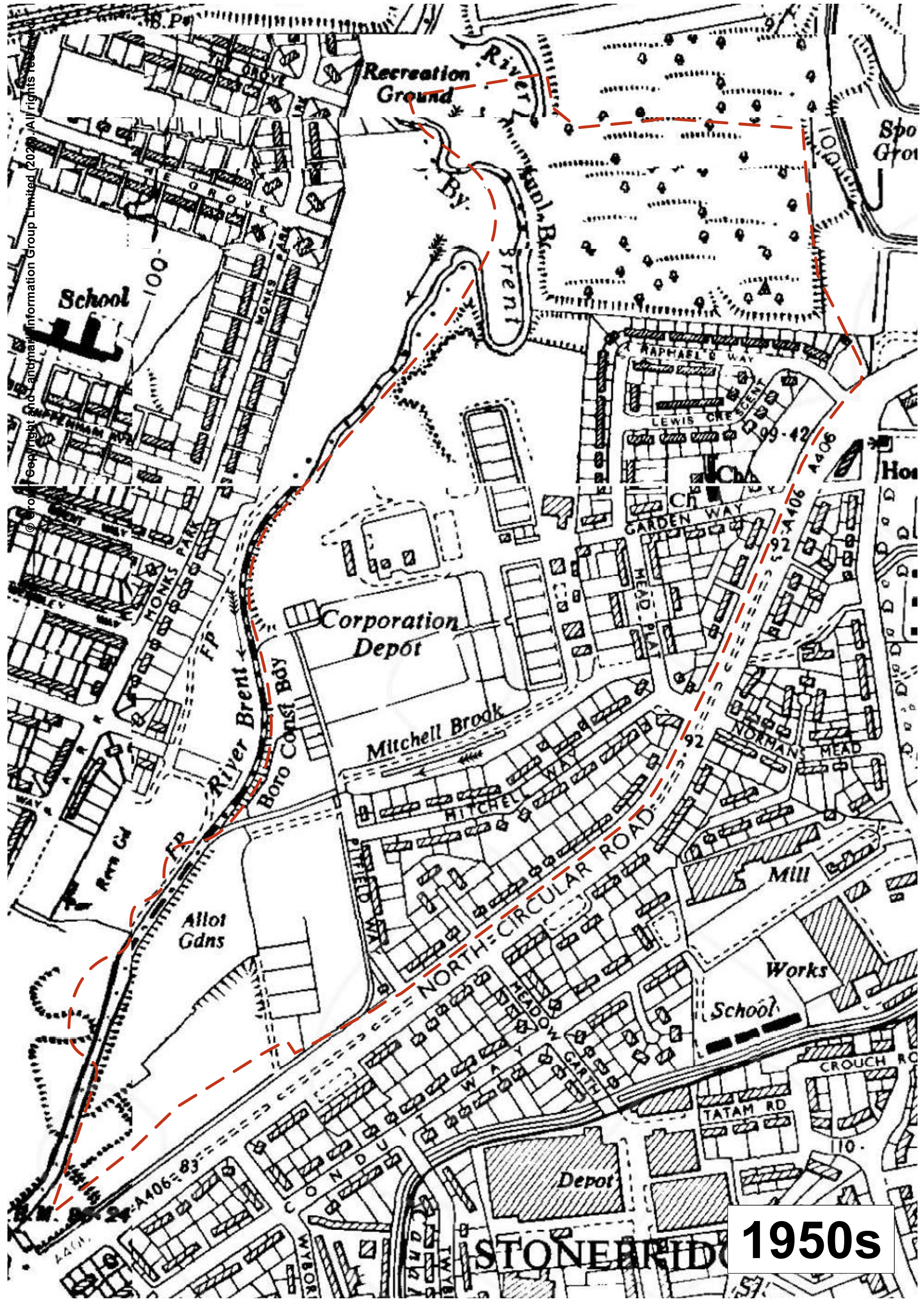
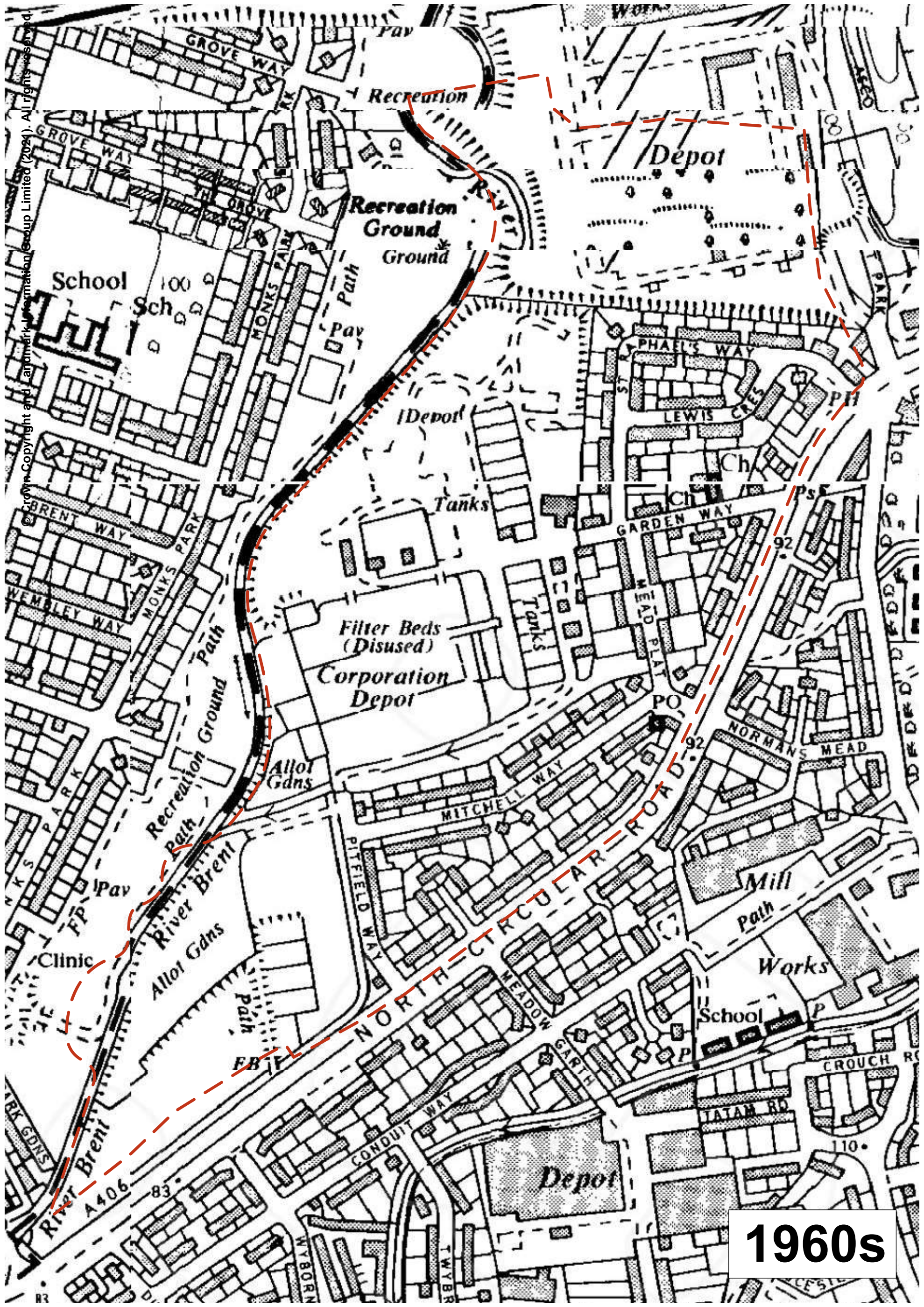
Weir
Sur. 97.7
Sur. 90.4
Stonebridge Farm
1870s


Willesden Local Board Sewage Farm
Filter Beds
Filter Beds
Wright's Farm
Lodge
Weir
Canal Feeder
Laundry
Stonebridge
B.M. 91.2
1890s


Union & U.D. By.
Filter Beds
Tanks
Isolation Hosp
Eve Field
(Cricket Ground)
Sewage Farm
(Willesden U.D. Council)
Old Filter Beds
Weir
Old Filter Beds
Posts
Canal
Laundry
Stonebridge Farm
1920s


School
Old Filter Beds
Old Filter Beds
Weir
Canal Feeder
MITCHELL WAY
NORTH CIRCULAR ROAD
CONDUIT WAY
1930s


Recreation Ground
School
Corporation Depot
Mitchell Brook
River Brent
Boro Const Bdy
Allot Gdns
NORTH CIRCULAR ROAD
Mill
Works
School
Depot
1950s



GROVE WAY
Recreation
Depot
Recreation Ground
Ground
River
School
Sch
MONKS PARK
Path
Pav
Depot
Tanks
ST RAPHAEL'S WAY
LEWIS CRES
Ch
PH
GARDEN WAY
BRENT WAY
WEMBLEY WAY
Filter Beds
(Disused)
Corporation
Depot
Tanks
MEAD PLAT
PO
92
NORMANS MEAD
Recreation Ground
Allot Gdns
MITCHELL WAY
PITFIELD WAY
NORTH CIRCULAR ROAD
Mill
Path
Works
River Brent
Allot Gdns
Clinic
Pav
FP
FB
MEADOW GARTH
School
CROUCH RD
TATAM RD
110
CONDUIT WAY
Depot
River Brent
A406
83
1960s