



**LSTC**  
GROUP

SCHEME: 110kV Eden – Castlereagh Overhead Line

**Buildability Report**

LSTC Reference - 49\_182245\_01



**CLIENT**

SONI Limited  
12 Manse Road  
Belfast  
BT6 9RT



## Document Control Sheet

**Project:** SONI 110kV

**Client:** SONI Limited

12 Manse Road

Belfast

BT6 9RT

**Document Title:** Line Refurbishment Buildability Report

**LSTC Reference:** 49\_182245\_01

**LSTC Office:** 1.27, Innovation Factory, 385 Springfield Rd, Belfast, Northern Ireland BT12  
7DG

	Author	Checked	Approved
<b>Name:</b>	David A Holmes	Robert Preston	Robert Preston
<b>Signature:</b>			
<b>Date:</b>	22/11/2019	26/11/2019	26/11/2019
<b>Revision:</b>	A	A	A
<b>Description:</b>	First Issue		

<b>Name:</b>	Oliver Cooper	Rob Preston	Robert Preston
<b>Signature:</b>			
<b>Date:</b>	28/05/2020	28/05/2020	28/05/2020
<b>Revision:</b>	B		
<b>Description:</b>	Minor amendments to Appendix 1 and 7		

<b>Name:</b>	Kevin Crossan	Rob Preston	Rob Preston
<b>Signature:</b>			
<b>Date:</b>	03/09/20	03/09/20	03/09/20
<b>Revision:</b>	C		
<b>Description:</b>	Minor amendments in line with SONI feedback		

This document is issued for the party which commissioned it for specific purposes connected with the above captioned project only. It should not be relied upon by any other party or used for any other purpose.

This document contains confidential information and proprietary intellectual property. It should not be shown to other parties or used by other parties without written consent from LSTC and from the party from which it was commissioned.



## Index of Contents

<b>1</b>	<b>Executive Summary- Access and Buildability</b>	<b>1</b>
<b>2</b>	<b>Introduction</b>	<b>6</b>
	2.1 Location	6
	2.2 LSTC	6
<b>3</b>	<b>Line Assessments</b>	<b>7</b>
	3.1 Eden - Carnmoney	7
	3.1.1 Tower Types	7
	3.1.2 Towers with Specific Issues during Stringing Operations	8
	3.1.3 Towers with Specific Issues for Access for Intrusive Foundation Inspections	8
	3.1.4 Discussions on Findings of Drive-Through Survey	8
	3.1.4.1 Background	8
	3.1.4.2 Civil Engineering Works	9
	3.1.4.3 Tower Steelwork Inspections & Renewal	9
	3.1.4.4 Stringing Operations	10
	3.1.4.5 Scaffolding Requirements	10
	3.1.4.6 Electrical Clearance Violations	11
	3.1.4.7 Summary of Findings	11
	3.2 Carnmoney – Finaghy	13
	3.2.1 Tower Types	13
	3.2.2 Towers with Specific Issues during Stringing Operations	13
	3.2.3 Towers with Specific Issues for Access for Intrusive Foundation Inspections	14
	3.2.4 Discussions on Findings of Drive-Through Survey	14
	3.2.4.1 Background	14
	3.2.4.2 Civil Engineering Works	15
	3.2.4.3 Tower Steelwork Inspections & Renewal	15
	3.2.4.4 Stringing Operations	15
	3.2.4.5 Scaffolding Requirements	16
	3.2.4.6 Electrical Clearance Violations	17
	3.2.4.7 Summary of Findings	18



3.3	Finaghy - Castlereagh	19
3.3.1	Tower Types	19
3.3.2	Towers with Specific Issues during Stringing Operations	19
3.3.3	Towers with Specific Issues for Access for Intrusive Foundation Inspections	20
3.3.4	Discussions on Findings of Drive-Through Survey	21
3.3.4.1	Background	21
3.3.4.2	Civil Engineering Works	21
3.3.4.3	Tower Steelwork Inspections & Renewal	21
3.3.4.4	Stringing Operations	22
3.3.4.5	Scaffolding Requirements	22
3.3.4.6	Electrical Clearance Violations	23
3.3.4.7	Summary of Findings	23
<b>4</b>	<b>Conclusions</b>	<b>25</b>
<b>5</b>	<b>References</b>	<b>27</b>

## **Appendices**

Appendix 1	Eden – Carnmoney Photographs
Appendix 2	Carnmoney – Finaghy Photographs
Appendix 3	Finaghy – Castlereagh Photographs
Appendix 4	Eden – Carnmoney Tower Access Drawing Numbers
Appendix 5	Carnmoney – Finaghy Tower Access Drawing Numbers
Appendix 6	Finaghy – Castlereagh Tower Access Drawing Numbers
Appendix 7	SONI: Castlereagh – Eden Scope of Work
Appendix 8	Norpower: Overhead Line Services – Budgetary Prices Report



## 1 Executive Summary – Access and Buildability

The line from Eden Main through to Castlereagh Main is in excess of 70 years old and was built using mainly the PL4 family of towers, also known as wartime grid reinforcement (WGR). A small number of towers are PL16 type used at terminal positions and for the diversion into Castlereagh Main (the line originally ran through to Rosebank Main). The conductors used are of two types, namely steel-cored copper and cadmium copper (both 0.5in<sup>2</sup> cross sectional area). The steel-cored copper conductor is deemed to be at end-of-life necessitating its replacement with a new conductor and to include a line rating increase if possible. The cadmium copper had still more than ten years life expectancy at the time of its last assessment but given the cost of scaffolding, set-up costs, etc. it may be more economic to replace it at the same time.

The purpose of this report is to highlight issues around accessing towers to allow intrusive foundation inspections to take place as well as to replace steelwork for corrosion or upgrading purposes. Access is also needed for re-insulating and re-stringing of the line.

### **Eden – Carnmoney (12.5 km)**

The line runs through the suburbs of Carrickfergus for the first 3.5 km before leaving the town and into open countryside. It re-enters housing at Mossley for the last 1.5 km. Near Eden Main two towers are to be completely replaced. The replacement of one tower should be straightforward as it is located in a small field but the other has the potential to cause considerable disruption to residents as it is very close to houses. There is a number of difficult sites near both substations where it will be difficult to position stringing equipment and it will need careful engineering input and management to minimise disruption during refurbishment works. There are at least eight locations where scaffolding would be required, one of which is at a railway crossing.

### *Summary of Feasibility of Line Refurbishment*

This overhead line will present a few localised, logistical problems in accessing a number of tower sites and in rectifying six spans with clearance infringements but it should be technically feasible to refurbish this line. More detailed work needs to be done to determine solutions to these infringements.



### **Carnmoney – Finaghy (14.5 km)**

The line runs for almost 2 km through housing from Carnmoney Main as far as the M2 motorway and there is a number of towers in this section that are 'land-locked'. If intrusive foundation investigations are required at every tower it will cause major disruption to home owners in terms of access and damage to gardens. A major scaffolding structure will be needed to protect motorway traffic during re-stringing operations. The line continues through an industrial area at Mallusk before climbing the hill between Mallusk and Belfast. This section is open, exposed countryside but as the line enters the west Belfast it immediately encounters housing and some towers at stringing positions will be difficult to access. For the last 3 km of line approaching Finaghy Main there is the potential for considerable land damage at a number of sites, if intrusive foundation inspections are needed, as many of the towers are 'land-locked' in back gardens with no simple access to them. In addition a number of stringing positions are beside very busy roads and major disruption to traffic is likely during stringing operations. A major scaffolding structure will be needed to protect traffic during re-stringing operations across the Whiterock Road/Springfield Road junction. In addition to this location and the M2 crossing there are at least sixteen other sites that require scaffolding.

#### *Summary of Feasibility of Line Refurbishment*

This overhead line will present numerous localised, logistical problems in accessing a number of tower sites and in rectifying eleven spans with potential clearance infringements but it should be technically feasible to refurbish this line. More detailed work needs to be done to determine solutions to these infringements. It is a more complex task than Eden – Carnmoney and will prove to be much more expensive due to increased scaffolding costs and traffic management.

### **Finaghy – Castlereagh (10.1 km)**

This line is mainly urban with only a few short lengths in open countryside. There are numerous locations where towers are 'land-locked' and access will be difficult. The first kilometre of this line is through dense housing and crosses the M1 motorway and the main-line railway line from Belfast to Lisburn/Dublin. Major scaffolding structures will be needed over the motorway and the railway as well as at a number of arterial routes through Belfast. There are fourteen sites in total that will require scaffolding and given their locations there is likely to be widespread traffic disruption.



### *Summary of Feasibility of Line Refurbishment*

This overhead line will also present numerous localised, logistical problems in accessing a number of tower sites and in rectifying eleven spans with potential clearance infringements but it should be technically feasible to refurbish this line. More detailed work needs to be done to determine solutions to these infringements. It is the shortest of the three lines but due to its more urban location it will present as many challenges as the others. The scaffolding required is more demanding than the other two lines due to the more critical road and rail crossings.

If access to every tower is required to carry out a full intrusive foundation inspection of at least one leg per tower there will be considerable costs incurred to correct land and property damage. Approximately 24 towers would involve disruption to householders and land damage in gardens and drives. If the easily accessed towers have foundation investigations completed and the findings are favourable a decision could be made not to try to access the remaining towers, other than for a visual inspection.

Stringing will be very difficult at a number of locations due to angle towers being located in back gardens or other restricted locations and being surrounded by housing with no space to easily set up stringing equipment. Square rigging may be feasible for a number, but not all, of these positions. It should also be possible to string straight through some angle towers dependent on the angle of line deviation.

The cost of refurbishing the line (or parts of the line) will have to be compared with the cost of undergrounding the line and recovering all conductors and towers. There will be elements associated with both options that will incur the same costs, eg scaffolding and some land damage. This will influence the decision-making process on the longer term asset investment. An overhead line contractor was commissioned to prepare a high-level costing of different options based on SONI's Scope of Work described in Appendix 7. The costs for these options, together with assumptions and caveats, can be found in Appendix 8. They, together with the technical difficulties described in this report and Network operation considerations, will assist in the decision-making process.



## **2 Introduction**

### **2.1 Location**

The overhead line which is the subject of this report begins at Ballylumford Power Station on Islandmagee and extends to Castlereagh Main substation on the southern side of Belfast. However the section from Ballylumford to Eden Main substation is excluded from the scope of this report as it is being addressed as a separate project. The line route includes a mixture of rural terrain with a significant length located in an urban setting which will present some challenging locations for future refurbishment, especially in areas of dense housing.

Approximate lengths of each section of line are as follows;

Eden Main – Carnmoney Main 12.5 km

Carnmoney Main – Finaghy Main 14.5 km

Finaghy Main – Castlereagh Main 10.1 km

### **2.2 LSTC**

LSTC were appointed by SONI to carry out an access and buildability report on the 110kV overhead line running from Eden Main to Carnmoney Main and on to Castlereagh Main via Finaghy Main. The electrical connection of this line to Finaghy Main was removed some years ago following a network reconfiguration but physically the line runs across the substation. This report highlights locations where access to towers will be difficult and where refurbishment, especially at some stringing positions, will be problematic due to tower locations within housing developments, as well as major road and railway crossings. This report should be read in conjunction with a comprehensive spreadsheet which includes information on each tower location as well as obstacles and hazards in each span between towers.



### 3 Line Assessments

#### Glossary of Terms

Term	Description
Accessibility Factor (1 – 5)	Degree of difficulty in accessing a tower due to distance from public road, access through housing or other obstacles or for stringing operations. Two groupings in tables – 1, 2 & 3 and 4 & 5.
Resident Nuisance Factor (1 – 5)	Degree of disruption caused to residents in terms of getting access to towers on property, stringing operations, traffic disruption, etc. Two groupings in tables – 1, 2 & 3 and 4 & 5.
Ahead Span Non-vegetation Clearance Violations	Clearance violations to ground, roads, buildings, street furniture, etc.

### 3.1 Eden – Carnmoney

#### 3.1.1 Tower Types

Tower Type	Number	Access. Score 1, 2 or 3	Access. Score 4 or 5	Resident Nuisance Factor 1, 2 or 3	Resident Nuisance Factor 4 or 5
D2/D2S	37	37	0	32	5
D10	5	5	0	1	4
D30	5	5	0	2	3
D60	2	2	0	1	1
DT	2	2	0	2	0
Total	51	51	0	38	13

Table 3.1.1a – Summaries of Accessibility Scores & Resident Nuisance Factors

Towers with Access or Resident Nuisance Issues	
<b>Accessibility Score</b>	<b>Tower Numbers</b>
1, 2 or 3	59 – 106A (All)
4 or 5	None
<b>Resident Nuisance Factor</b>	<b>Tower Numbers</b>
1, 2 or 3	59 – 64, 65A, 67 – 71, 73 – 82, 87 – 94, 96 – 100, 104, 106A
4 or 5	65, 66, 72, 83 – 86, 95, 101 – 103, 105 & 106
<b>Accessibility Score &amp; Resident Nuisance Factor (both)</b>	<b>Tower Numbers</b>
4 or 5	None

Table 3.1.1b - Towers with Access and/or Resident Nuisance Issues

#### 3.1.2 Towers with Specific Issues during Stringing Operations (all tension towers unless noted otherwise)



Tower 59 – tower inside perimeter fence of Eden Main substation with limited room for setting up machinery. Square rigging required and special procedures.

Tower 66 – limited space for stringing in both directions. Square rigging required.

Tower 72 – tower is adjacent to a short avenue which will be blocked by stringing operations and hence will cause a lot of disruption to residents.

Tower 83 – very tall tower beside horse riding arena. Good access for stringing on one side but square rigging needed for the back span.

Towers 85 & 86 – beside fairways of Greenisland golf course and difficult stringing position on one side of each tower.

Tower 95 – difficult stringing position on one side.

Tower 101 - difficult stringing position on one side.

Tower 105 – beside shopping area with very restricted stringing area. String through best option.

Tower 106A – tower inside perimeter fence of Carnmoney Main substation with limited room for setting up machinery. Square rigging required and special procedures.

### **3.1.3 *Towers with Specific Issues Regarding Access for Intrusive Foundation Inspections***

Tower 62 – tower in back garden.

Tower 65 – tower behind wall in cul-de-sac.

Towers 102, 103, 104 & 106 – towers in back gardens with limited access.

Wayleave access for 104 blocked.

### **3.1.4 *Discussion on Findings of Drive-Through Survey***

#### **3.1.4.1 Background**

The line from Eden to Carnmoney passes through a number of built-up areas on the northern side of Carrickfergus emerging into farmland as it leaves the town at a suburb called Woodburn. At the time of its original construction it would have passed through mainly farmland but as Carrickfergus developed as a dormer town for people working mainly in Belfast the area between Eden Main substation and Woodburn (approximately 15 spans/ 3.3 km) was used for numerous housing developments. A few locations in this section will present challenges for intrusive tower foundation



investigations and for some stringing positions. In addition there are two towers identified for total replacement and replacing one of them will cause considerable disruption. On leaving Carrickfergus at Woodburn the line runs through farmland, together with two golf courses, before reaching Mossley. The last section of 6 spans/1.4 km at Mossley runs over a railway and through dense housing with a small number of towers being landlocked by housing, making access difficult.

### 3.1.4.2 Civil Engineering Works

All tower sites can be accessed for any reason but for a number of them in areas of dense housing, considerable damage will be caused in getting excavation machinery in to carry out intrusive foundation inspections. If remedial foundation work is required considerably more damage may be caused, dependent on the extent of the works required. In table 3.1.4.2 below it can be seen that a large number of suspension towers will require work carried out to them to ensure compliance with specifications.

<b>Towers with Foundation Over-Utilisations</b>	
<b>Suspension Towers</b>	
<i>Utilisation Factor %</i>	<i>Tower Numbers</i>
0 - 84	65A
85 - 99	59A, 61, 62, 63, 64 65, 69, 70, 71, 73, 74, 76, 79, 80 & 88
100 and above	60, 67, 68, 75, 77, 81, 84, 90, 91, 92, 93, 94, 96, 97, 98, 99, 100, 102, 103, 104 & 106
<b>Tension Towers</b>	
<i>Utilisation Factor %</i>	<i>Tower Numbers</i>
85 - 99	None
100 and above	None

Table 3.1.4.2 – Towers with Foundation Over-Utilisations

### 3.1.4.3 Tower Steelwork Inspections and Steelwork Renewal

The steelwork inspection for this line was completed by others (under an NIE Networks instruction) where a number of towers (23) were visited and a full steelwork assessment carried out. The inspection documentation was processed and diagrams showing bars needing to be replaced were produced, together with material lists. Two towers have extensive corrosion and have been identified for total replacement, ie towers 63 and 65, while others have varying degrees of corrosion.



It is NIE Networks' intention to have a complete steelwork assessment survey done during early 2019.

#### 3.1.4.4 Stringing Operations

A full and detailed appraisal of each potential stringing location would need to be carried out to determine the most advantageous locations for setting up machinery in terms of accessibility and practicality of location. The housing around many tower sites should not present many difficulties at suspension towers but where a tension tower needs to be used as a stringing position there are numerous sites where difficulties will be encountered, requiring special access and stringing arrangements. Stringing operations at such sites are likely to cause localised disruption to local residents. A number of difficult stringing positions may be avoided by running through tension towers where the angle of deviation isn't excessive. The length of conductor that can be supplied on one drum may be a limiting factor. It is assumed that the use of mid-span joints will be avoided.

In particular tower numbers 66, 72, 83, 85, 86, 95, 101 & 105 will cause considerable disruption during stringing.

#### 3.1.4.5 Scaffolding Requirements

The table below shows the locations of where major scaffold structures will be needed, eg the North Road, Woodburn Road, mainline railway, etc. Scaffolding structures at these locations will cause considerable disruption during their erection and later removal and in most cases will require road or rail closures to allow their erection and subsequent recovery. The requirement for scaffolding at some locations not listed may be determined by the stringing techniques to be employed by the contractor carrying out the work. Detailed discussion would be required with the contractor with regard to the risks involved and the methods to be used.

<b>Major Road &amp; Railway Scaffolding Requirements</b>	
<b>Major road or railway crossing</b>	<b>Ahead Span Number</b>



North Road (2 lanes)	67
Woodburn Road (2 lanes)	72
Upper Road (2 lanes)	76
Old Carrickfergus Road (2 lanes)	101
Railway (Belfast – Antrim)	101
Beverley Road	105
Carnmoney Road	105
Note	
There is a total of 8 road/rail crossings that may require scaffolding dependent on techniques used and extent of work	

Table 3.1.4.5 – Scaffolding Requirements at Major Road & Railway Crossings

### 3.1.4.6 Electrical Clearance Violations (if strung with UPAS)

Ahead Span Non-Vegetation Clearance Violations (UPAS)				
Ahead Span No.	Violations at Design Operating Temperatures (DOT)			Solution
	50°C	65°C	75°C	
71	N/A	N/A	Building	To be investigated
73	N/A	Survey point	Survey point	
86	N/A	Survey point	Survey point	
87	N/A	Survey point	Survey point	
89	N/A	Other wires	Other wires	
100	N/A	Survey point	Survey point	

Table 3.1.4.6 – Non-Vegetation Clearance Violations

### 3.1.4.7 Summary of Findings

It is apparent that there will be considerable technical and logistical challenges to overcome in carrying out the refurbishment of this line between Eden Main substation and Carnmoney Main substation. Many of the issues will centre around the close proximity of houses to towers and the difficulty in accessing them and minimising damage. The technical difficulties that may be most difficult to solve may be the resolution of electrical clearance violations. Some, but not all, disappear when the proposed design operating temperature is reduced but that would require a compromise on the preferred electrical rating of the line. More in-depth work is required to determine solutions. There are 6 occurrences that will need further investigation



Scaffolding requirements will be extensive and, by implication, expensive to implement but it is likely that these costs will be the same or indeed higher if ultimately a decision is made to recover the line, or sections of it, and replace it with underground cable circuits. The existing conductor can be used as a bond to restring each circuit but subject to confirmation of its residual strength from the condition assessment report carried out by others. Restringing the line will negate the need for additional scaffolding to protect housing in a number of locations for removal of conductor. Costs for this scaffolding or other equipment to protect roofs could be substantial at a number of locations on this line, especially between Eden Main substation and the North Road in Carrickfergus, and between the Old Carrickfergus Road near Mossley and Carnmoney Main substation.

Stringing operations will be difficult at a number of tension towers due to their locations beside main roads or surrounded by housing. However some of these towers can be strung through meaning that stringing machines will not be needed at these towers. Special rigging should allow towers with a high angle of deviation and difficult access to be accommodated.

The access requirements to all towers to carry out intrusive foundation inspections will present particular difficulties. There are towers that are completely enclosed by gardens and access, although not impossible, will cause considerable disruption to homeowners, with inevitable costs to reinstate properties to their former condition.

This line has been inspected to identify potential steelwork issues with 2 towers having been proposed for total replacement.



### 3.2 Carnmoney – Finaghy

#### 3.2.1 Tower Types

Tower Type	Number	Access. Score 1, 2 or 3	Access. Score 4 or 5	Resident Nuisance Factor 1, 2 or 3	Resident Nuisance Factor 4 or 5
D2 or D2S	49	48	1	32	17
D10 or DD10	6	6	0	4	2
D30	3	3	0	1	2
D60	1	1	0	1	0
DT or DDT	2	2	0	2	0
Total	61	60	1	40	21

Table 3.2.1a – Summaries of Accessibility Scores & Resident Nuisance Factors

Towers with Access or Resident Nuisance Issues	
Accessibility Score	Tower Numbers
1, 2 or 3	106B – 148 & 150 - 161
4 or 5	149
Resident Nuisance Factor	Tower Numbers
1, 2 or 3	106B, 113 – 115, 117 – 145, 147 & 148, 150, 160A & 161
4 or 5	107 – 112, 116, 146, 149, 151 - 160
Accessibility Score & Resident Nuisance Factor (both)	Tower Numbers
4 or 5	149

Table 3.2.1b - Towers with Access and/or Resident Nuisance Issues

#### 3.2.2 Towers with Specific Issues during Stringing Operations (all tension towers unless noted otherwise)

Tower 106B - tower inside perimeter fence of Carnmoney Main substation with limited room for setting up machinery. Square rigging required and special procedures.

Tower 107A – tower is completely land-locked with no easy access even for square rigging. String through.

Tower 110 – tower in back garden with no stringing positions. String through.

Tower 115 – located in commercial premises with limited space. Square rigging.

Tower 134 – restricted space both sides.



Tower 146 – very difficult location with housing on back span and no access. Tower sits beside a very busy road and a lot of disruption would be caused to residents.

Machines would sit on road and use square rigging on tower.

Tower 151 – Located at busy crossroads. Stringing would cause major disruption.

Low AOD so string through.

Tower 159 – Walk-in access to tower only and no simple way of square rigging.

Low AOD so string through.

Tower 161 - tower inside perimeter fence of Finaghy Main substation with limited room for setting up machinery. Square rigging required and special procedures.

### **3.2.3 Towers with Specific Issues Regarding Access for Intrusive Foundation Inspections**

Towers 107 – 112 – towers in gardens with limited access. Considerable damage likely.

Towers 114 & 115 – towers in commercial premises. Disruption to operations.

Tower 145 – tower accessed using a pathway and very close to houses.

Tower 146 – tower at the side of a busy road and very close to houses.

Towers 150 – 160A – towers in back gardens, or very close to houses and roads.

Major disruption to some home-owners and residents if excavations are needed.

### **3.2.4 Discussion on Findings of Drive-Through Survey**

#### **3.2.4.1 Background**

The line from Carnmoney to Finaghy passes through built-up areas of Carnmoney, Glengormley, Mallusk and west Belfast. At the time of its original construction it would have passed through mainly farmland but the subsequent need for housing, industrial units and road infrastructure improvements over many years have now introduced many challenging tower sites along its route, relating to access for investigations, inspections and eventual remedial works.



### 3.2.4.2 Civil Engineering Works

<b>Towers with Foundation Over-Utilisations</b>	
<b>Suspension Towers</b>	
<i>Utilisation Factor %</i>	<i>Tower Numbers</i>
0 - 84	108A
85 - 99	110A, 113A, 144, 148, 149
100 and above	All other suspension towers (43 off) fail on either compression or uplift
<b>Tension Towers</b>	
<i>Utilisation Factor %</i>	<i>Tower Numbers</i>
85 - 99	None
100 and above	None

Table 3.2.4.2 – Towers with Foundation Over-Utilisations

### 3.2.4.3 Tower Steelwork Inspections and Steelwork Renewal

The steelwork inspection for this line was completed by others (under an NIE Networks instruction) where a number of towers (11) were visited and a full steelwork assessment carried out. The inspection documentation was processed and diagrams showing bars needing to be replaced were produced, together with material lists. There were varying degrees of corrosion found in the sample towers inspected, especially in the area above Mallusk where a number of towers were highlighted as needing a lot of replacement bars. This is an area where historically bars had to be changed on towers adjacent to the upper Hightown quarry. The drive-through inspection carried out recently identified numerous towers on this line that it is understood present access issues for painting due to being in close proximity to houses and a considerable number of towers showed visible corrosion (photographs available), eg Manse Road, Ballyhenry, New Barnsley and Turf Lodge. Damage may be caused where tower leg and bracing steelwork need to be replaced at ground level, necessitating ground works with associated land damage. In some sites new steelwork may require a considerable amount of manual handling to transport it in before work to replace it can begin.

It is NIE Networks' intention to have a complete steelwork assessment survey done during early 2019.

### 3.2.4.4 Stringing Operations

A full and detailed appraisal of each potential stringing location would need to be carried out to determine the most advantageous locations for setting up machinery in terms of accessibility and practicality of location. The housing around many tower



sites should not present many difficulties at suspension towers but where a tension tower needs to be used as a stringing position there are numerous sites where difficulties will be encountered, requiring special access and stringing arrangements. Stringing operations at such sites are likely to cause localised disruption to local residents. A number of difficult stringing positions may be avoided by running through tension towers where the angle of deviation isn't excessive. The length of conductor that can be supplied on one drum may be a limiting factor. It is assumed that the use of mid-span joints will be avoided.

In particular stringing at tower numbers 107A, 110 & 159 may cause considerable disruption.

#### **3.2.4.5 Scaffolding Requirements**

The table below shows the locations of where major scaffold structures will be needed, eg the Prince Charles Way, Ballyclare Road, M2, etc. Scaffolding structures at these locations will cause considerable disruption during their erection and later removal and in most cases will require road or rail closures to allow their erection and subsequent recovery. In particular scaffolding needed to string over the M2 motorway and its associate slip roads will be substantial as will the junction of the Whiterock Road and Springfield Road. The requirement for scaffolding at some locations not listed may be determined by the stringing techniques to be employed by the contractor carrying out the work. Detailed discussion would be required with the contractor with regard to the risks involved and the methods to be used. Some minor road crossings have not been listed but may have to be considered.



<b>Major Road &amp; Railway Scaffolding Requirements</b>	
<b>Major road or railway crossing</b>	<b>Ahead Span Number</b>
Prince Charles Way (2 lanes)	108
Ballyclare Road (2 lanes)	109
Carwood Avenue (2 lanes)	110
Antrim Road (2 lanes)	113
M2 on-slip, M2, M2 off-slip (8 lanes)	113A
Scullion's Road (4 lanes)	114
Mallusk Road (4 lanes)	115
Hydepark Road (2 lanes)	119
Boghill Road (2 lanes)	120
Flush Road (2 lanes)	130
Ballyutoag Road (2 lanes)	131
Ballymagarry Road (2 lanes)	146
Springfield Road & Whiterock Road junction	151
Monagh By-pass (4 lanes)	155
Glen Road (4 lanes)	156
Andersonstown Road (4 lanes)	160
Finaghy Road North (2 lanes)	160A
Note	
There is a total of 17 road crossings that may require scaffolding dependent on techniques used and extent of work. Roads listed above are on busy routes.	

Table 3.2.4.5 – Scaffolding Requirements at Major Road & Railway Crossings

### 3.2.4.6 Electrical Clearance Violations (if restrung with UPAS)

<b>Ahead Span Non-Vegetation Clearance Violations (UPAS)</b>				
<b>Ahead Span No.</b>	<b>Violations at Design Operating Temperatures (DOT)</b>			<b>Solution</b>
	<b>50°C</b>	<b>65°C</b>	<b>75°C</b>	
109	N/A	N/A	Building	To be investigated
114	Survey point	Survey point	Survey point	
131	N/A	Other wires	Other wires	
141	Survey point	Survey point	Survey point	
142	N/A	Other wires	Other wires	
146	Survey point	Survey point	Survey point	
149	Building	Building	Building	
150	N/A	N/A	Building	
153	N/A	N/A	Building	
158	Building	Building	Building	
159	Building	Building	Building	

Table 3.2.4.6 – Non-Vegetation Clearance Violations



### 3.2.4.7 Summary of Findings

It is apparent that there will be considerable technical and logistical challenges to overcome in carrying out the refurbishment of this line between Carnmoney Main substation and Finaghy Main substation. Many of the issues will centre around the close proximity of houses to towers and the difficulty in accessing them and minimising damage. The technical difficulties that may be most difficult to solve may be the resolution of electrical clearance violations. Some, but not all, disappear when the proposed design operating temperature is reduced but that would require a compromise on the preferred electrical rating of the line. More in-depth work is required to determine solutions.

Scaffolding requirements will be extensive and, by implication, expensive to implement but it is likely that these costs will be the same or indeed higher if ultimately a decision is made to recover the line, or sections of it, and replace it with underground cable circuits. The existing conductor can be used as a bond to restring each circuit but subject to confirmation of its residual strength from the condition assessment report carried out by others. Restringing the line will negate the need for additional scaffolding to protect housing in a number of locations for removal of conductor. Costs for this scaffolding or other equipment to protect roofs could be substantial in a number of locations on this line, especially between Carnmoney Main substation and the Mallusk Road and the Ballygomartin Road, Springfield Road, Andersonstown Road and Finaghy Road North housing areas.

Stringing operations will be difficult at a number of tension towers due to their locations beside main roads or surrounded by housing. However some of these towers can be strung through meaning that stringing machines will not be needed at these towers. Special rigging should allow towers with a high angle of deviation and difficult access to be accommodated.

The access requirements to all towers to carry out intrusive foundation inspections will present particular difficulties. There are towers that are completely enclosed by gardens and access, although not impossible, will cause considerable disruption to homeowners, with inevitable costs to reinstate properties to their former condition.

This line has been fully inspected to identify potential steelwork issues and these reports are available separately but in carrying out a drive-through survey a number of towers were identified as having major steelwork corrosion which will need more extensive remedial action, potentially requiring total replacement of towers.



### 3.3 Finaghy – Castlereagh

#### 3.3.1 Tower Types

Tower Type	Number	Access. Score 1, 2 or 3	Access. Score 4 or 5	Resident Nuisance Factor 1, 2 or 3	Resident Nuisance Factor 4 or 5
D2/D2S	27	24	3	25	2
D10	4	0	4	2	2
D30	4	2	2	2	2
D60	5	3	2	4	1
DT	2	2	0	2	0
Total	42	31	11	35	7

Table 3.3.1a – Summaries of Accessibility Scores & Resident Nuisance Factors

Towers with Access or Resident Nuisance Issues	
Accessibility Score	Tower Numbers
1, 2 or 3	1, 3, 4, 5, 8, 9, 11, 11A, 12, 13, 14, 18, 19, 21, 22, 23, 24, 25, 27, 28, 29, 30, 32, 33, 34, 35, 36, 37, 37A, 37B, 38
4 or 5	2, 6, 7, 10, 15, 16, 17, 20, 26, 31, 33A
Resident Nuisance Factor	Tower Numbers
1, 2 or 3	1, 3, 4, 5, 6, 8, 9, 10, 11, 11A, 13, 14, 15, 16, 17, 18, 19, 21, 23, 24, 25, 27, 28, 29, 30, 32, 33, 33A, 34, 35, 36, 37, 37A, 37B, 38
4 or 5	2, 7, 12, 20, 22, 26, 31
Accessibility Score & Resident Nuisance Factor (both)	Tower Numbers
4 or 5	2, 7, 20, 26, 31

Table 3.3.1b - Towers with Access and/or Resident Nuisance Issues

#### 3.3.2 Towers with Specific Issues during Stringing Operations (all tension towers unless noted otherwise)

Towers 2 & 3 (suspension) – special tension insulator sets installed on tower leg on one phase to correct an historic clearance violation. Survey has highlighted a continuing violation if strung with UPAS, but semi-tension sets may be a solution.

Tower 7 – very difficult location to string at due to location beside houses and day care nursery school. Stringing through is only solution.

Tower 15 – very steep terrain but can be used as stringing position.



Tower 16 – tower surrounded by trees. Stringing through is only solution.

Tower 17 – difficult stringing position on one side due to trees. Square rigging required.

Tower 20 – difficult stringing position beside hotel car park. Stringing through is only solution.

Tower 26 – difficult position to string at although square rigging is an option using small car parking area.

Tower 31 - very difficult location to string at due to location behind houses. May be possible to square rig tower from ahead span in small valley.

Towers 33 & 33A (suspension) – towers are landlocked in back gardens with access difficult for foundation investigations.

### **3.3.3 Towers with Specific Issues Regarding Access for Intrusive Foundation Inspections**

Tower 2 – difficult access through back garden. Considerable undergrowth to remove.

Tower 6 – difficult access through back garden.

Tower 7 – access via drive but large conifer trees growing in and close to tower.

Tower 11 – tower between back gardens with access past an RMU restricted.

Tower 12 – tower in front garden but considerable damage will be caused if excavating around one leg.

Tower 16 – access difficult and some mature trees will need to be removed to allow machinery in.

Tower 20 – difficult site as tower base is elevated above adjacent roadway and restricted access generally.

Tower 30 – very difficult access.

Tower 31 – very difficult access for excavating around tower.

Towers 33, 33A & 34 – all have very difficult accesses through gardens causing considerable damage.



### 3.3.4 Discussion on Findings of Drive-Through Survey

#### 3.3.4.1 Background

The line from Finaghy to Castlereagh passes through many built-up areas of west and south Belfast. At the time of its original construction it would have passed through mainly farmland but the subsequent need for housing and road infrastructure improvements over many years have now introduced many challenging tower sites along its route, relating to access for investigations, inspections and eventual remedial works.

#### 3.3.4.2 Civil Engineering Works

All tower sites can be accessed for any reason but for many of them in areas of dense housing, considerable damage will be caused in getting excavation machinery in to carry out intrusive foundation inspections. If remedial foundation work is required considerably more damage may be caused, dependent on the extent of the works required.

<b>Towers with Foundation Over-Utilisations</b>	
<b>Suspension Towers</b>	
<i>Utilisation Factor %</i>	<i>Tower Numbers</i>
0 - 84	2, 4 & 11A
85 - 99	9, 11, 14, 18, 19, 21, 22, 23, 24, 25, 27, 28, 33 & 33A
100 and above	3, 10, 13, 29, 30, 32, 34, 35, 36 & 37A
<b>Tension Towers</b>	
<i>Utilisation Factor %</i>	<i>Tower Numbers</i>
85 - 99	None
100 and above	None

Table 3.3.4.2 – Towers with Foundation Over-Utilisations

#### 3.3.4.3 Tower Steelwork Inspections and Steelwork Renewal

The steelwork inspection for this line was completed by others (under an NIE Networks instruction) where a number of towers (8) were visited and a full steelwork assessment carried out. The inspection documentation was processed and diagrams showing bars needing to be replaced were produced, together with material lists. There were varying degrees of corrosion found in the sample towers inspected. The drive-through inspection carried out recently identified numerous towers on this line that it is understood present access issues for painting due to being in close proximity to houses and a considerable number of towers showed visible corrosion (photographs available), eg Upper Malone, Belvoir, Mount Michael areas of south



Belfast. Damage may be caused where tower leg and bracing steelwork need to be replaced at ground level, necessitating ground works with associated land damage. In some sites new steelwork may require a considerable amount of manual handling to transport it in before work to replace it can begin.

It is NIE Networks' intention to have a complete steelwork assessment survey done during early 2019.

#### **3.3.4.4 Stringing Operations**

A full and detailed appraisal of each potential stringing location would need to be carried out to determine the most advantageous locations for setting up machinery in terms of accessibility and practicality of location. The housing around many tower sites should not present many difficulties at suspension towers but where a tension tower needs to be used as a stringing position there are numerous sites where difficulties will be encountered, requiring special access and stringing arrangements. Stringing operations at such sites are likely to cause localised disruption to local residents. A number of difficult stringing positions may be avoided by running through tension towers where the angle of deviation isn't excessive. The length of conductor that can be supplied on one drum may be a limiting factor. It is assumed that the use of mid-span joints will be avoided.

In particular stringing at tower numbers 7, 12, 20, 31 may cause considerable disruption.

#### **3.3.4.5 Scaffolding Requirements**

The table below shows the locations of where major scaffold structures will be needed, eg M1 motorway, mainline railway, Lisburn Road, Belvoir Road, etc. Scaffolding structures at these locations will cause considerable disruption during their erection and later removal and in most cases will require road or rail closures to allow their erection and subsequent recovery. In particular scaffolding needed to string over the M1 motorway and its associate slip roads will be substantial. The requirement for scaffolding at some locations may be determined by the stringing techniques to be employed by the contractor carrying out the work. Detailed discussion would be required with the contractor with regard to the risks involved and the methods to be used. Some minor road crossings have not been listed but may have to be considered.



<b>Major Road &amp; Railway Scaffolding Requirements</b>	
<b>Major road or railway crossing</b>	<b>Ahead Span Number</b>
M1 motorway (6 lanes)	3
Railway (Belfast – Dublin, 2 lines)	5
Lisburn Road (4 lanes)	7
Upper Malone Road (2 lanes)	12
Milltown Road (4 lanes)	19
Belvoir Road (dual carriageway with 4 lanes)	26
Saintfield Road (4 lanes)	29
Manse Road (2 lanes)	37B
Note	
There is a total of 14 road/railway crossings that may require scaffolding dependent on techniques used and extent of work. Not all are listed above.	

Table 3.3.4.5 – Scaffolding Requirements at Major Road & Railway Crossings

### 3.3.4.6 Electrical Clearance Violations (if restrung with UPAS)

The table in below highlights spans where electrical clearance violations have been identified using PLS CADD software. A more detailed analysis of these will need to be completed to identify the most acceptable resolution of these clearances. It may be determined that there is no easy technical solution that doesn't incur substantial cost or resistance from residents.

<b>Ahead Span Non-Vegetation Clearance Violations (UPAS)</b>				
<b>Ahead Span No.</b>	<b>Violations at Design Operating Temperatures (DOT)</b>			<b>Solution</b>
	<b>50°C</b>	<b>65°C</b>	<b>75°C</b>	
1	N/A	Building	Building	To be investigated
2	N/A	Building	Building	
8	Survey point	Survey point	Survey point	
14	N/A	N/A	Building	
21	Building	Building	Building	
24	N/A	Building	Building	
25	Survey point	Survey point	Survey point	
26	N/A	Survey point	Survey point	
28	N/A	N/A	Building	
30	Building	Building	Building	

Table 3.3.4.6 – Non-Vegetation Clearance Violations

### 3.3.4.7 Summary of Findings

It is apparent that there will be considerable technical and logistical challenges to overcome in carrying out the refurbishment of this line between Finaghy Main



substation and Castlereagh Main substation. Many of the issues will centre around the close proximity of houses to towers and the difficulty in accessing them and minimising damage. The technical difficulties that may be most difficult to solve may be the resolution of electrical clearance violations. Some, but not all, disappear when the proposed design operating temperature is reduced but that would require a compromise on the preferred electrical rating of the line. More in-depth work is required to determine solutions.

Scaffolding requirements will be extensive and, by implication, expensive to implement but it is likely that these costs will be the same or indeed higher if ultimately a decision is made to recover the line, or sections of it, and replace it with underground cable circuits. The existing conductor can be used as a bond to restring each circuit but subject to confirmation of its residual strength from the condition assessment report carried out by others. Restringing the line will negate the need for additional scaffolding to protect housing in a number of locations for removal of conductor. Costs for this scaffolding or other equipment to protect roofs could be substantial in a number of locations on this line, especially between Finaghy Main substation and the Lisburn Road, Belvoir estate, Beechill, Newtownbreda and Mount Michael housing areas.

Stringing operations will be difficult at a number of tension towers due to their locations beside main roads or surrounded by housing. However some of these towers can be strung through meaning that stringing machines will not be needed at these towers. Special rigging should allow towers with a high angle of deviation and difficult access to be accommodated.

The access requirements to all towers to carry out intrusive foundation inspections will present particular difficulties. There are towers that are completely enclosed by gardens and access, and although not impossible, will cause considerable disruption to homeowners, with inevitable costs to reinstate properties to their former condition.

This line has not been fully inspected to identify potential steelwork issues but in carrying out a drive-through survey a number of towers were identified as having major steelwork corrosion at ground level which would need more extensive remedial action, potentially affecting stubs.



## **4 Conclusions**

### **4.1 Eden – Carnmoney (12.5 km)**

The discussion of the findings in Section 3.1.4.7 of this report highlights the various technical issues associated with refurbishing and uprating this line. This line has a large section running through open countryside (approximately 7.3 km between Tower No. 74 and Tower No. 101) and this will mean these sections will be relatively straightforward to refurbish and upgrade although four out of the six clearance violations which would exist if the line was restrung with UPAS will need resolved in this section. The remainder of the line has access issues at each end which will prove difficult, but not impossible, to resolve. Overall, of the three lines covered by this report, this line will have the least difficulty in upgrading it to the required standard.

### **4.2 Carnmoney – Finaghy (14.5 km)**

The discussion of the findings in Section 3.2.4.7 of this report highlights the various technical issues associated with refurbishing and uprating this line. Like Eden – Carnmoney there is a long middle section which runs through open countryside on high ground close to 300m AOD (approximately 6.3 km between Tower No. 120 and Tower No. 143). There is a number of towers from Carnmoney Main as far as the M2 motorway that have awkward accesses and intrusive foundation investigations will cause considerable damage and disruption so there may have to be compromises made, using investigations from other accessible towers as a basis for estimating the adequacy of these tower foundations for the increase in tower loadings, to decide what remedial work needs done. This will also apply on the line from Tower No. 143 in to Finaghy Main. Careful investigations into the resolution of potential clearance violations will need to be carried out as there may not be easy solutions to some of them, there are five violations to buildings in this section. The engineering solutions, though possible, may be expensive to apply, especially if foundations need to be upgraded in difficult locations such as back gardens.

### **4.3 Finaghy - Castlereagh (10.1km)**

The discussion of the findings in Section 3.3.4.7 of this report highlights the various technical issues associated with refurbishing and uprating this line. This is the shortest of the three lines covered in this report but given the major roads and



railway crossing it crosses it will incur substantial scaffolding costs. Sections between Tower No. 7 and Tower No. 10, Tower No. 13 and Tower No. 20, and Tower No. 34 and Tower No. 38 are all in open areas of the city or in farmland near Castlereagh Main substation (approximately 3.2 km in total). The remainder is in housing with some towers having very difficult accesses. As per Carnmoney – Finaghy there are potential clearance violations to buildings to address (six in total) and again these may prove difficult to resolve easily.

Ultimately all three of these lines could be refurbished and upgraded but there have to be decisions made on the asset 'life expectancy' left for each line, the cost of repairing steelwork, upgrading/repairing foundations, removing clearance violations, etc. and then comparison made with the cost of possible recovery and replacement of all or part of each of the lines with underground cable circuits.



## 5 References

This report must be read in conjunction with the documents listed below;

- |              |   |
|--------------|---|
| 02_182245_02 | Ballylumford – Castlereagh Line Information Schedule  |
| 60_17336_XXX | Steelwork Assessment Drawing Series. These drawings only cover the sample of towers inspected during climbing inspections. The inspection of tower steelwork is to be repeated by NIE Networks. |
| 49_17336_10  | BPS – Eden – Carnmoney – Finaghy – Castlereagh 110kV OHL Conductor Comparison Report  |
| 6/025:2007   | NIE Networks Policy for Clearances to Overhead Lines: Issue 2   |

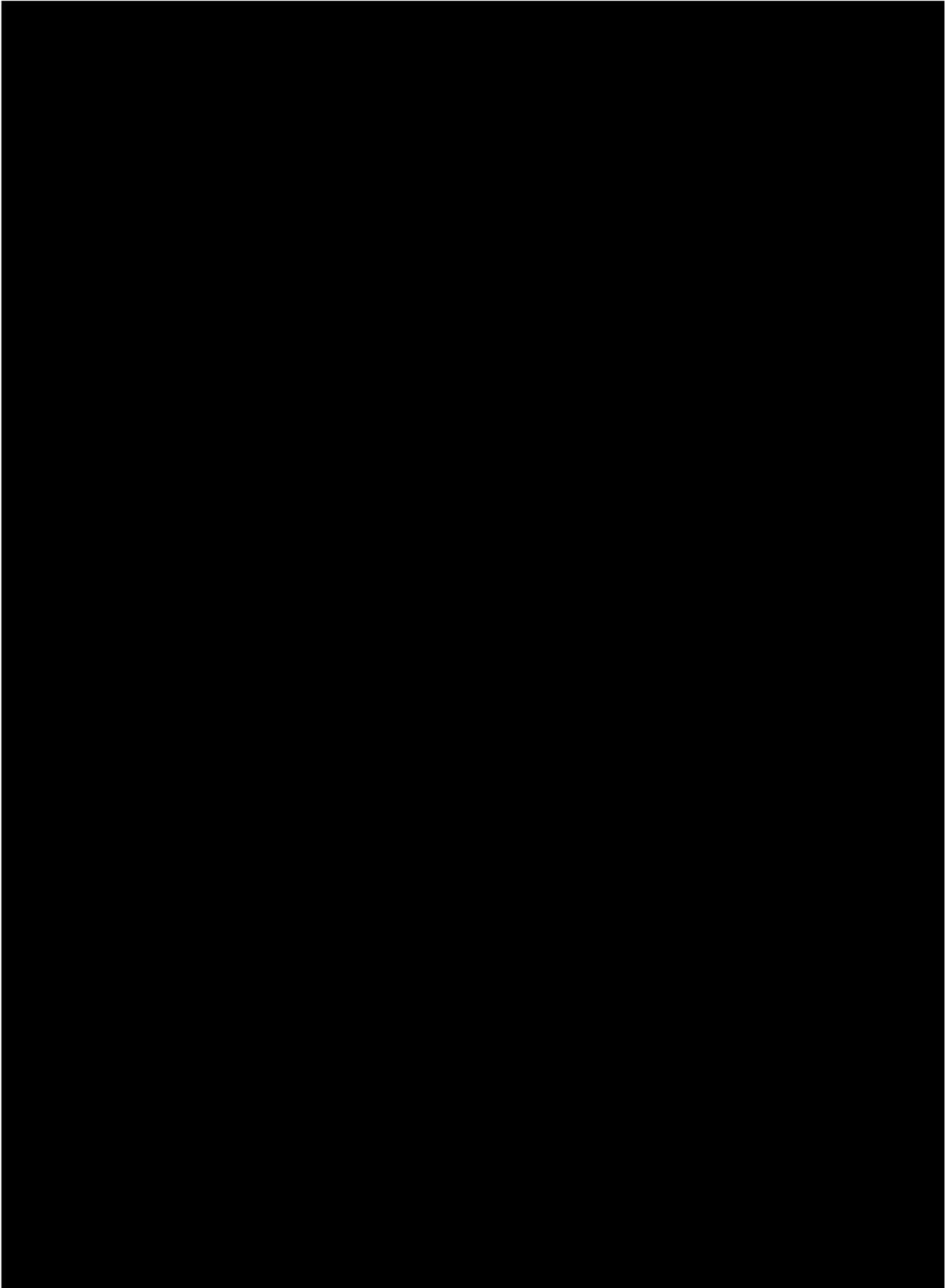


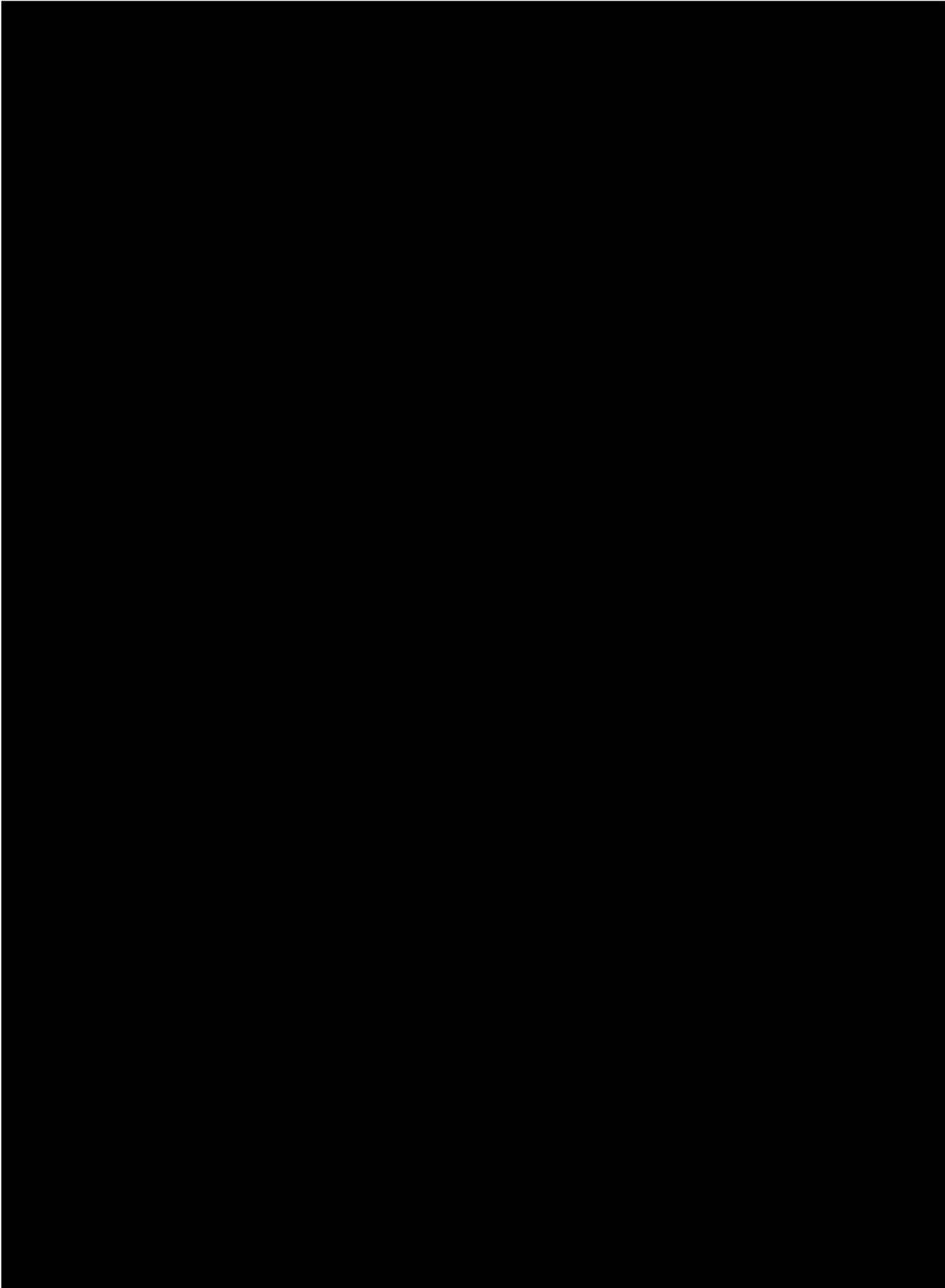
## Appendices

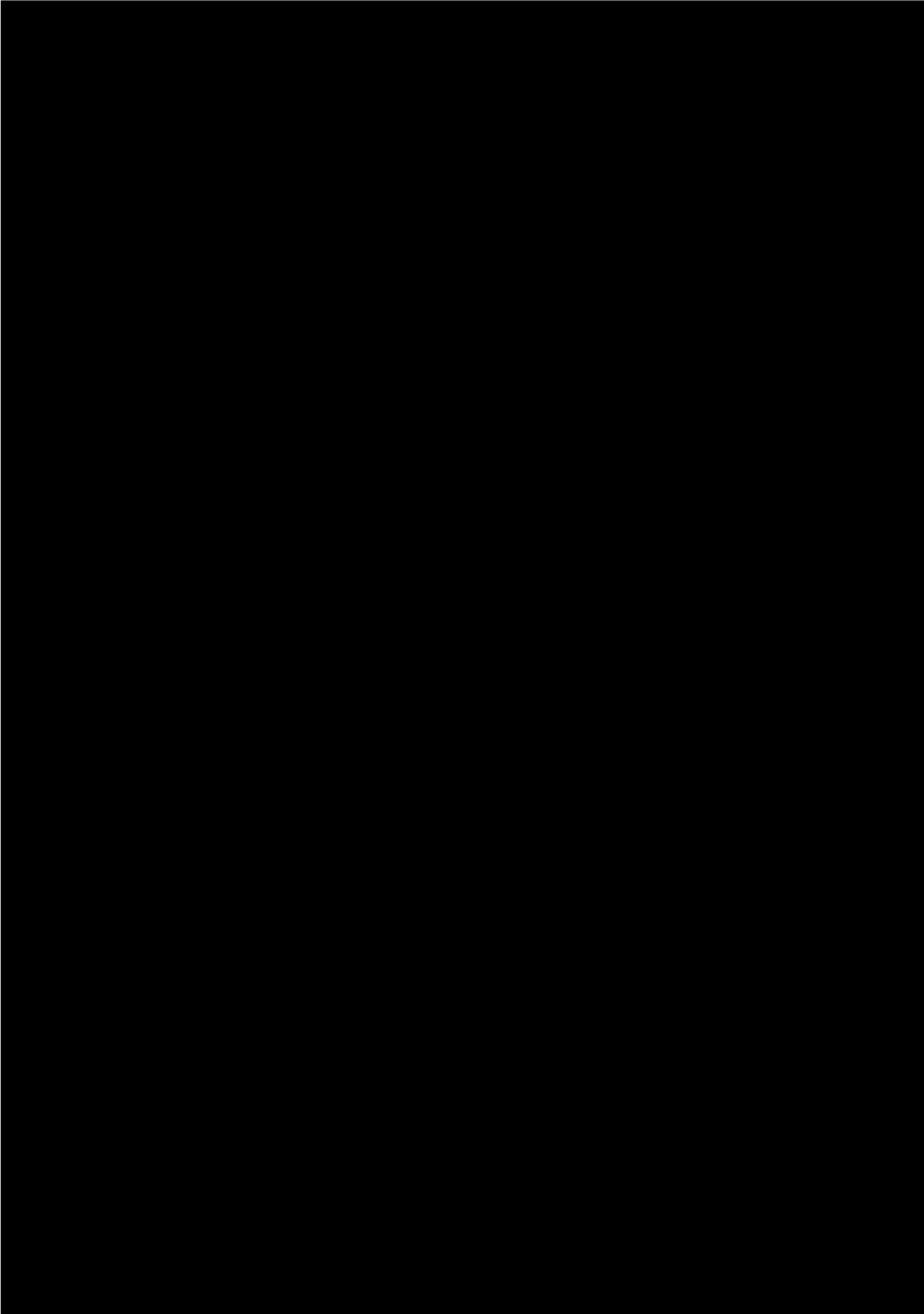
- Appendix 1 Eden – Carnmoney Photographs
- Appendix 2 Carnmoney – Finaghy Photographs
- Appendix 3 Finaghy – Castlereagh Photographs
- Appendix 4 Eden – Carnmoney Photographs
- Appendix 5 Carnmoney – Finaghy Photographs
- Appendix 6 Finaghy – Castlereagh Photographs
- Appendix 7 SONI: Castlereagh – Eden Scope of Work
- Appendix 8 Norpower: Overhead Line Services – Budgetary Prices Report

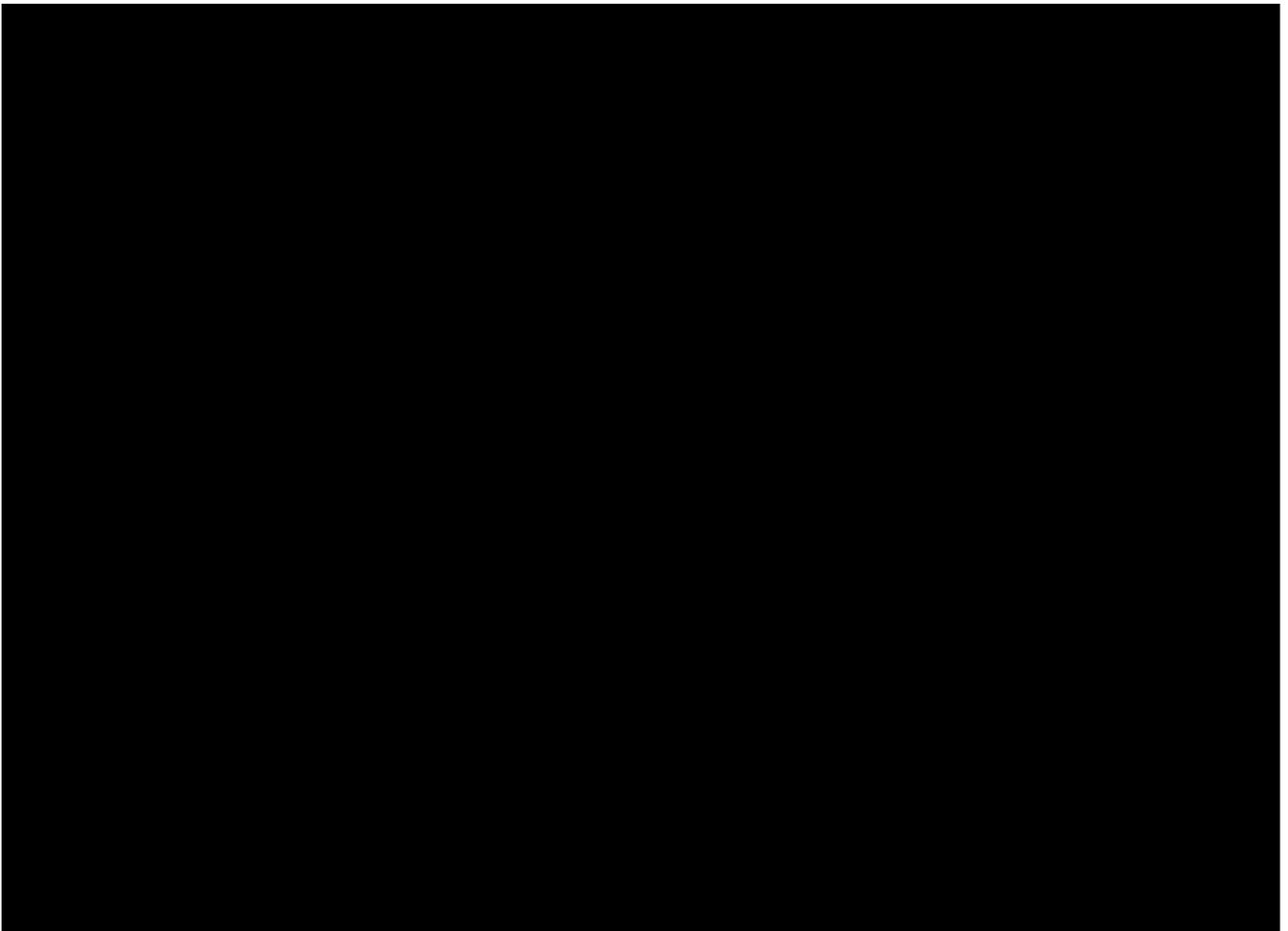
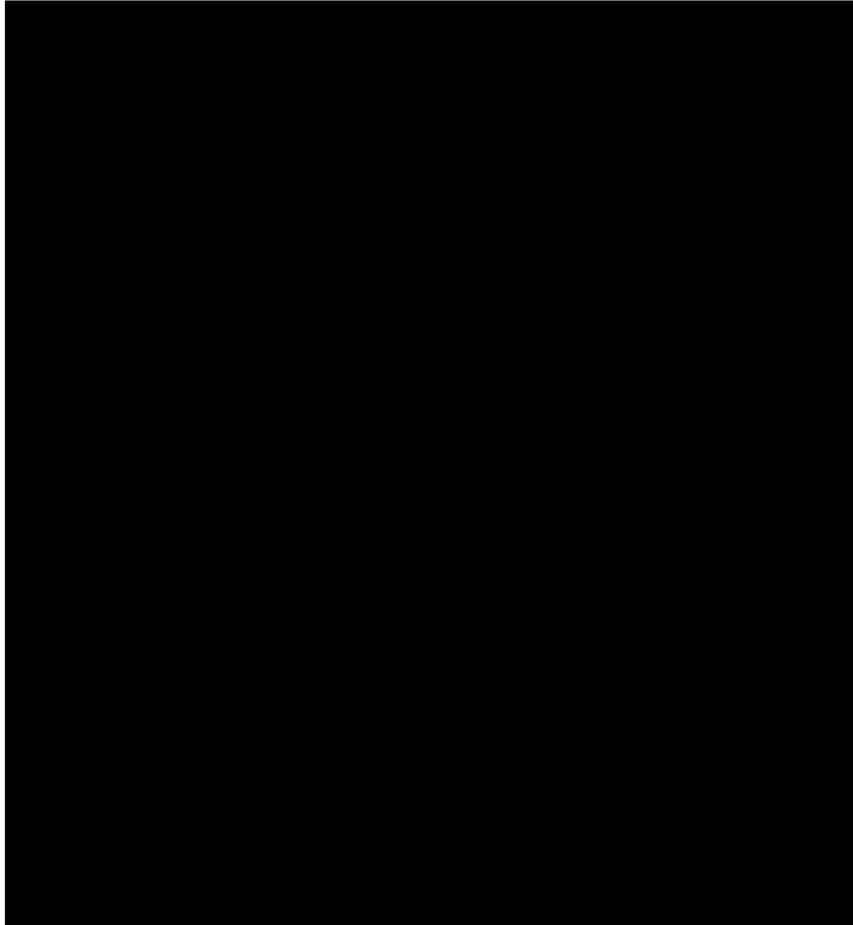


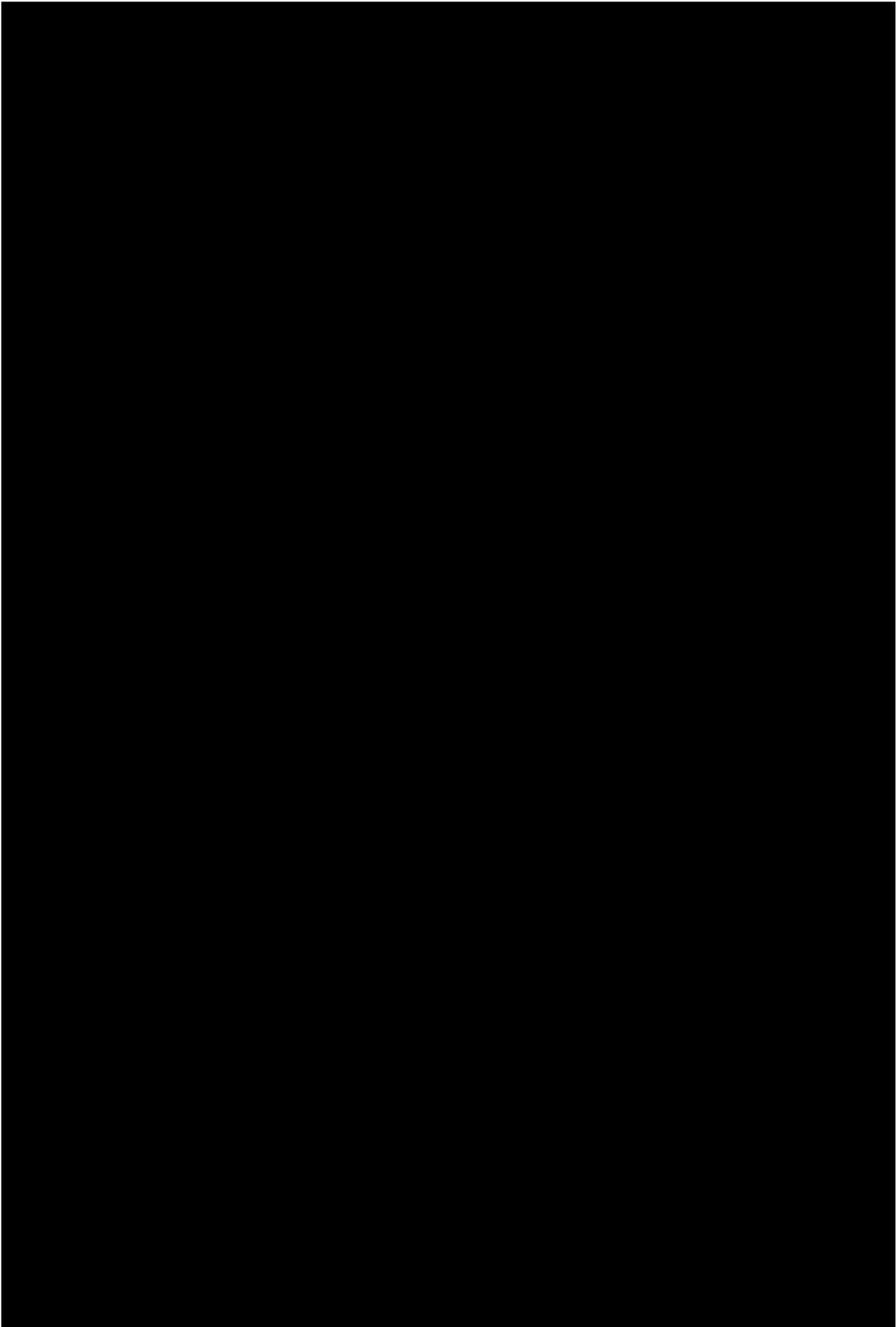
## **Appendix 1: Eden – Carnmoney Photographs**

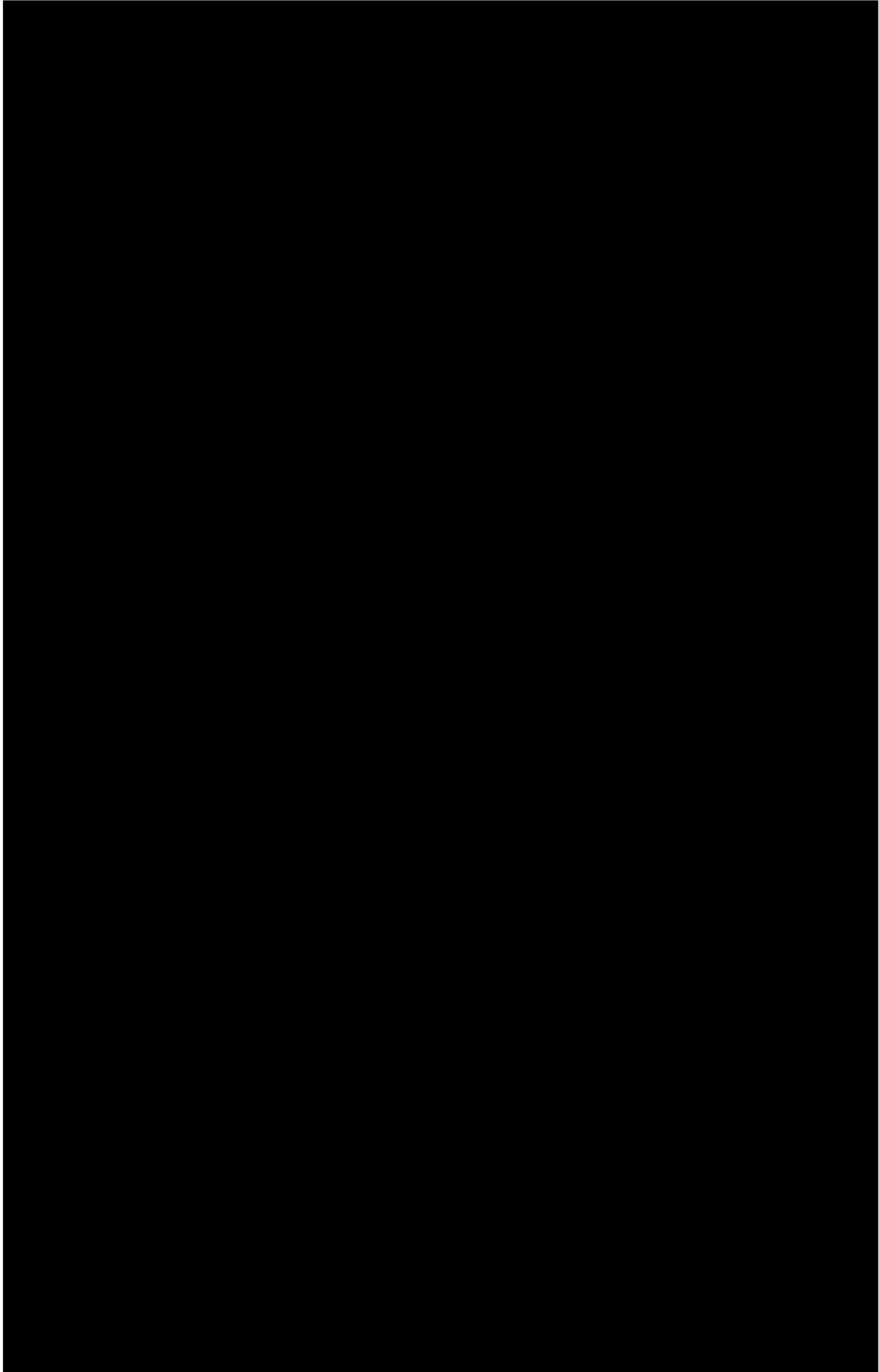


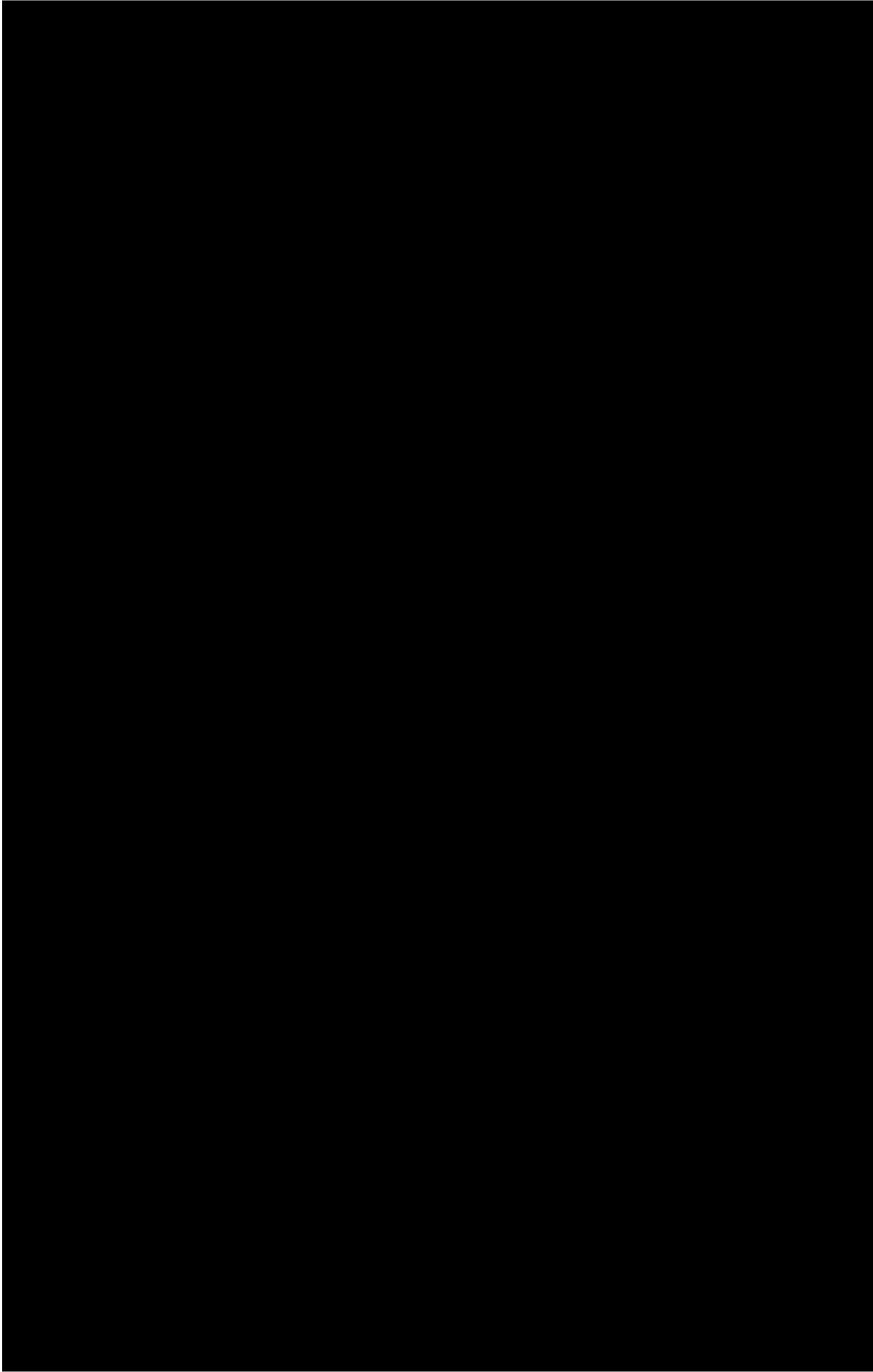


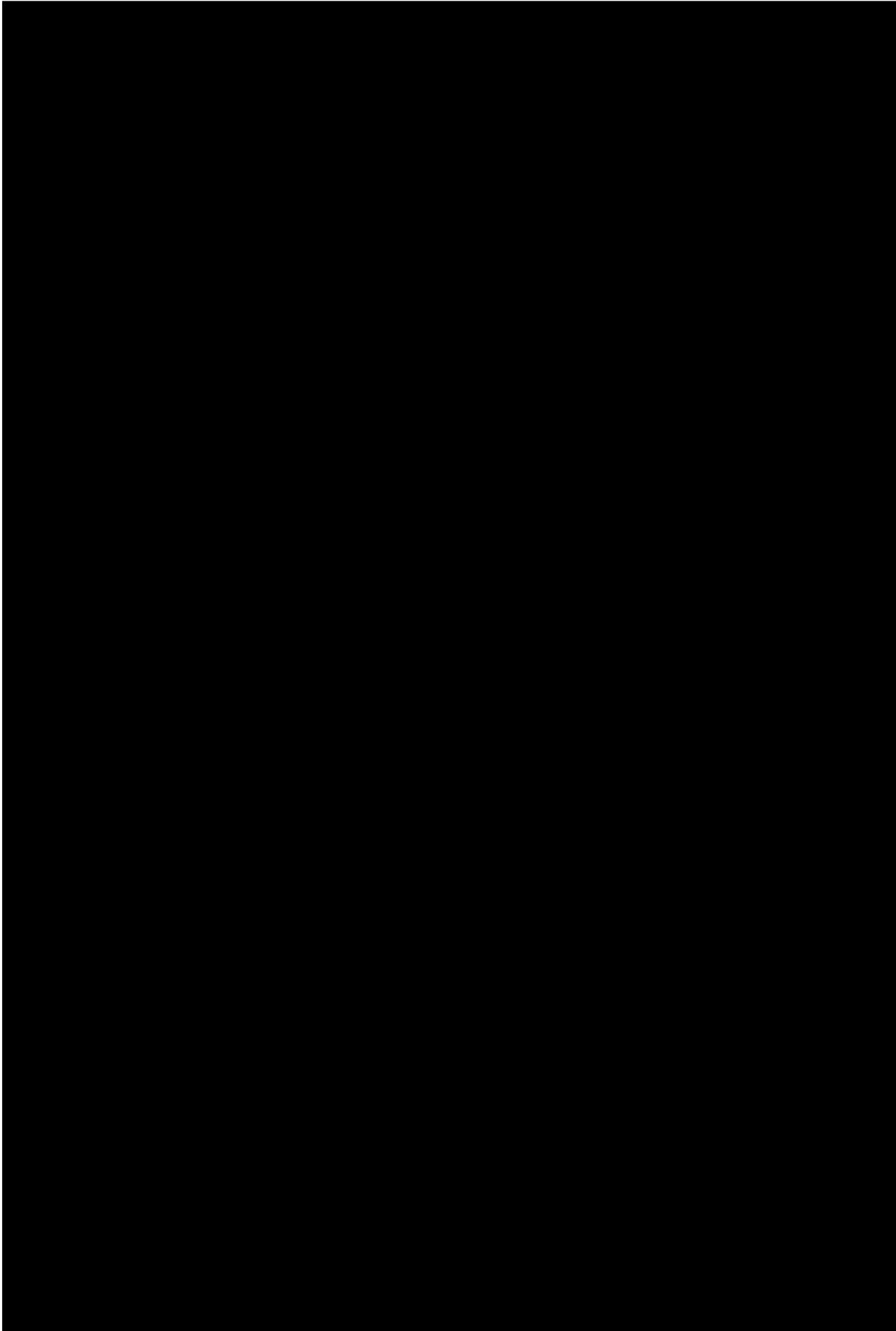






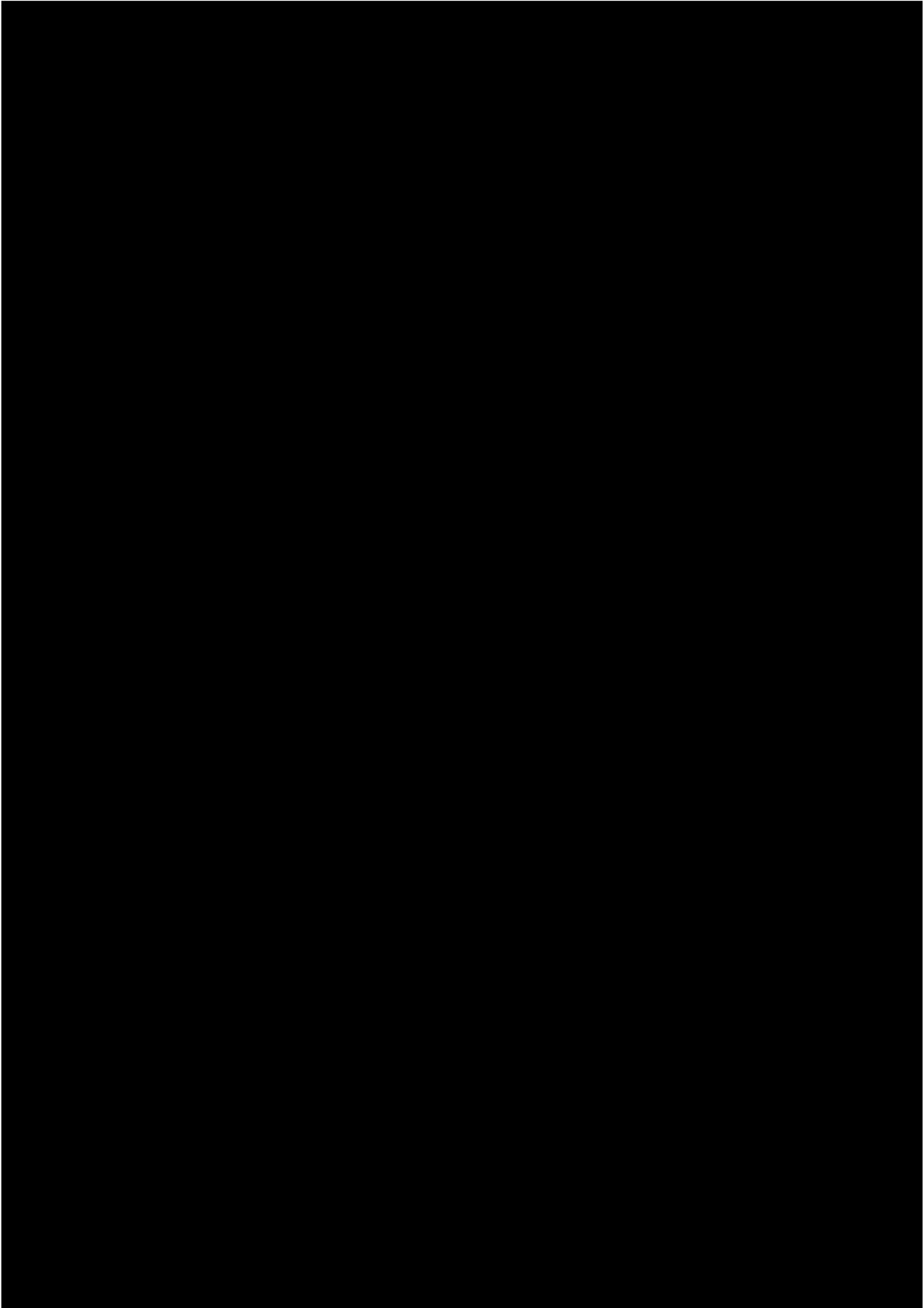


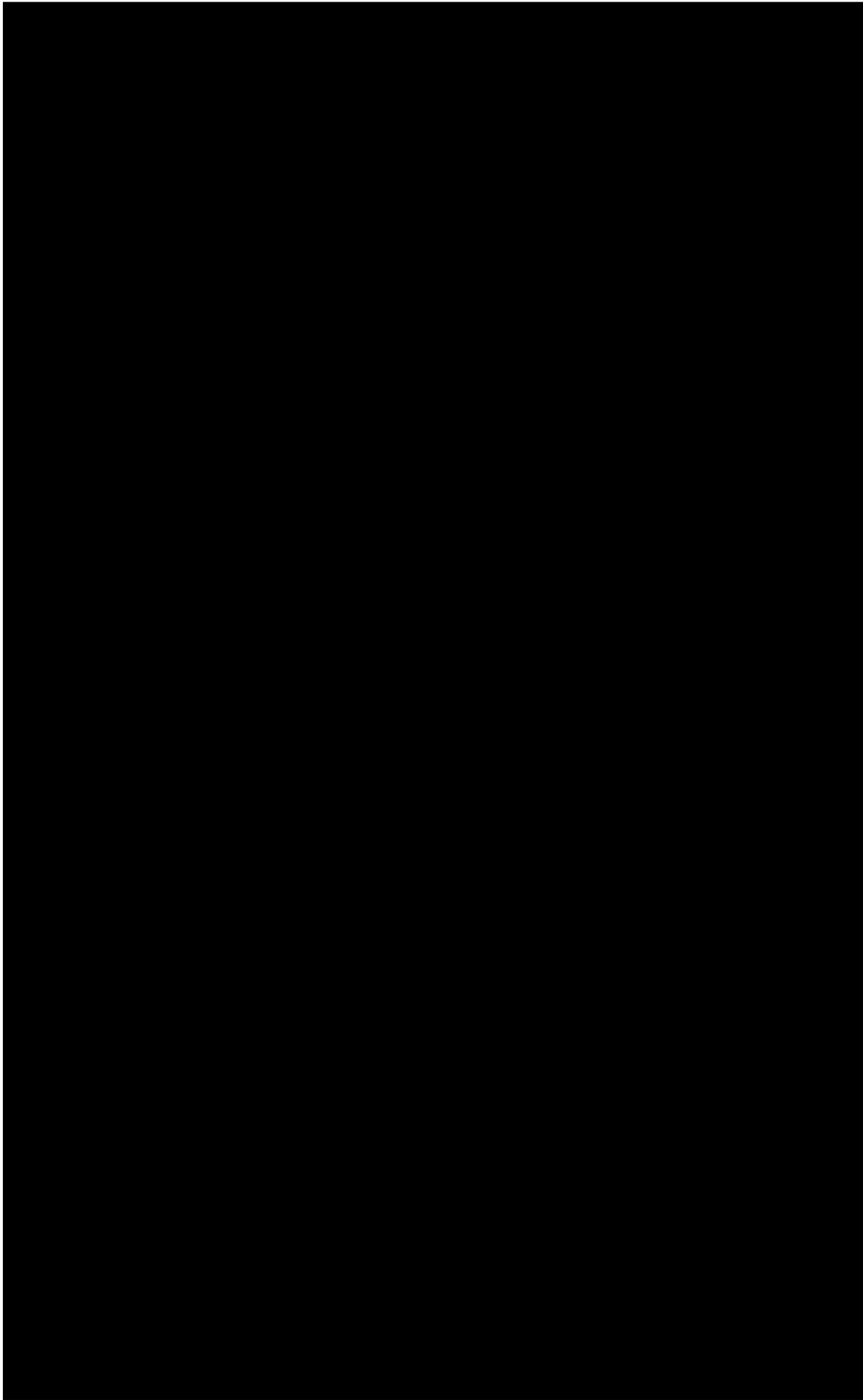


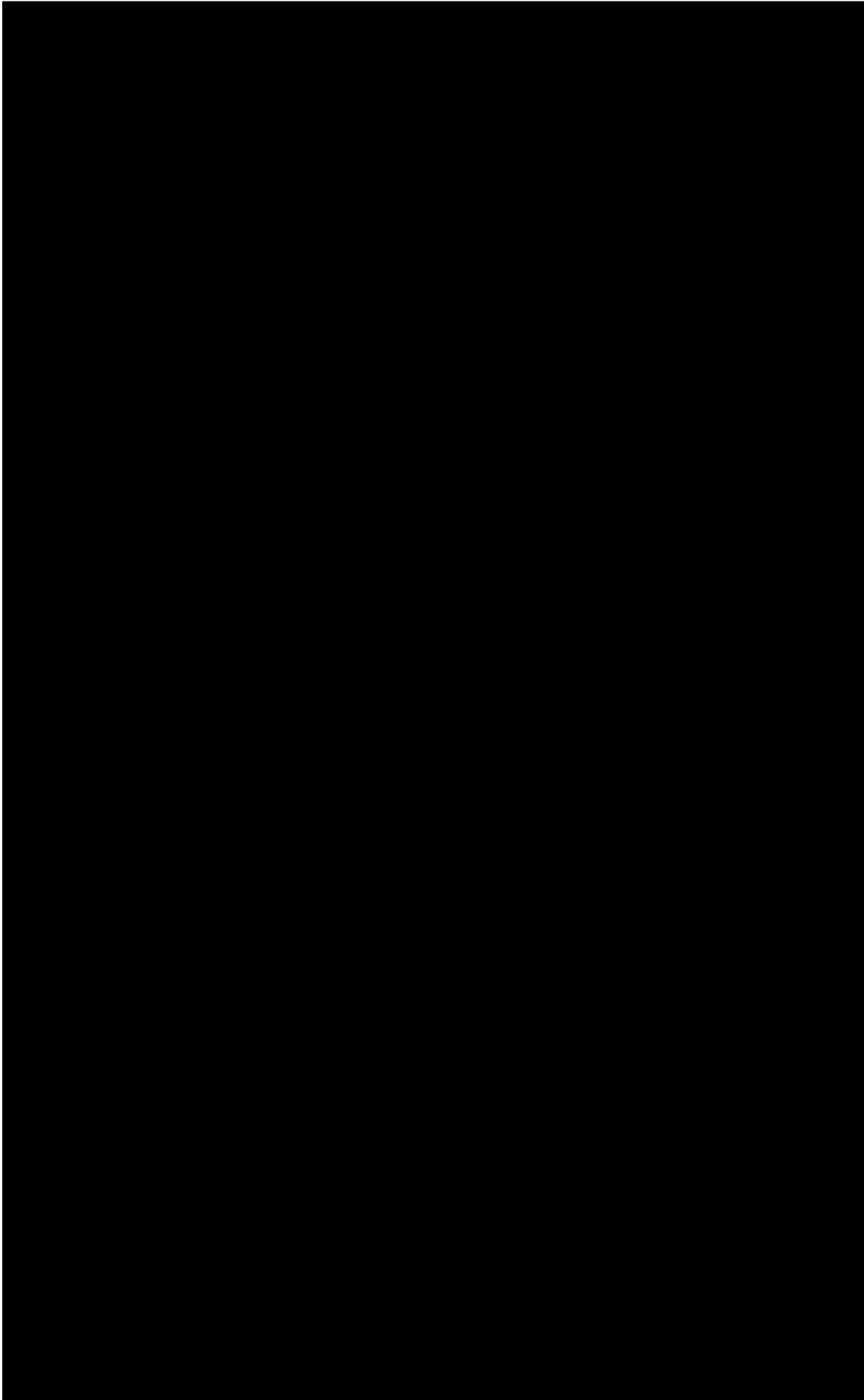


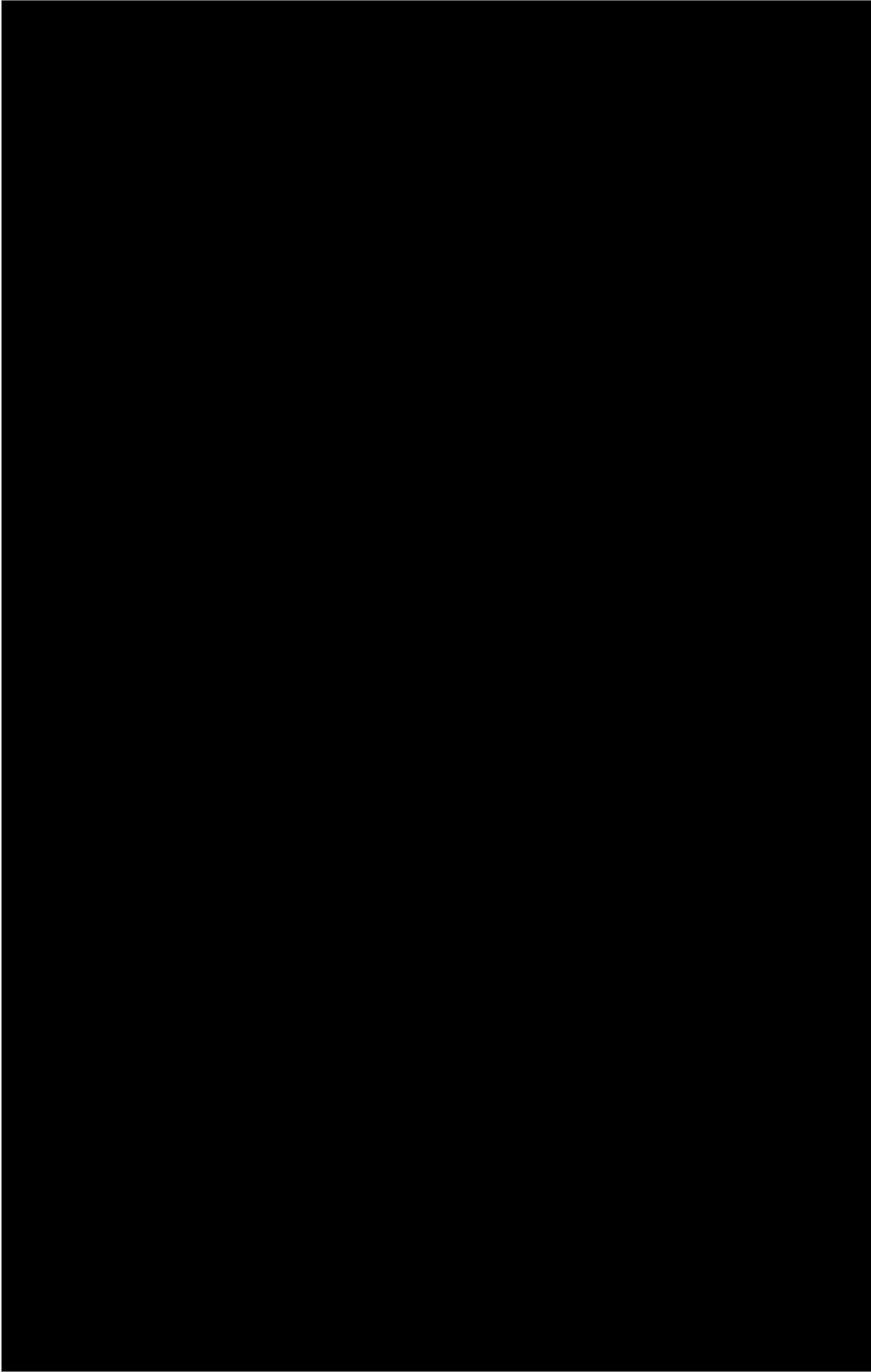


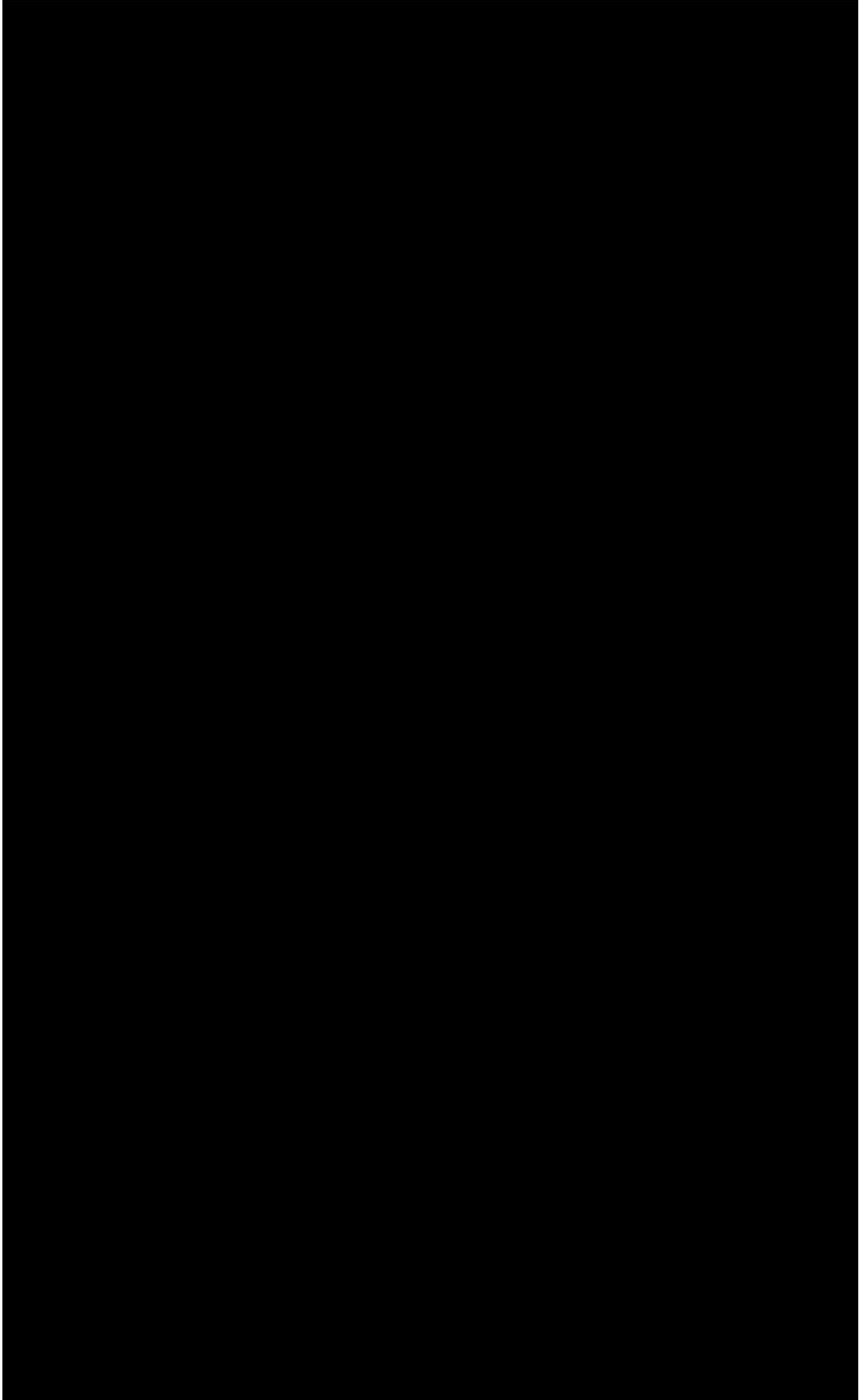
## **Appendix 3: Finaghy – Castlereagh Photographs**



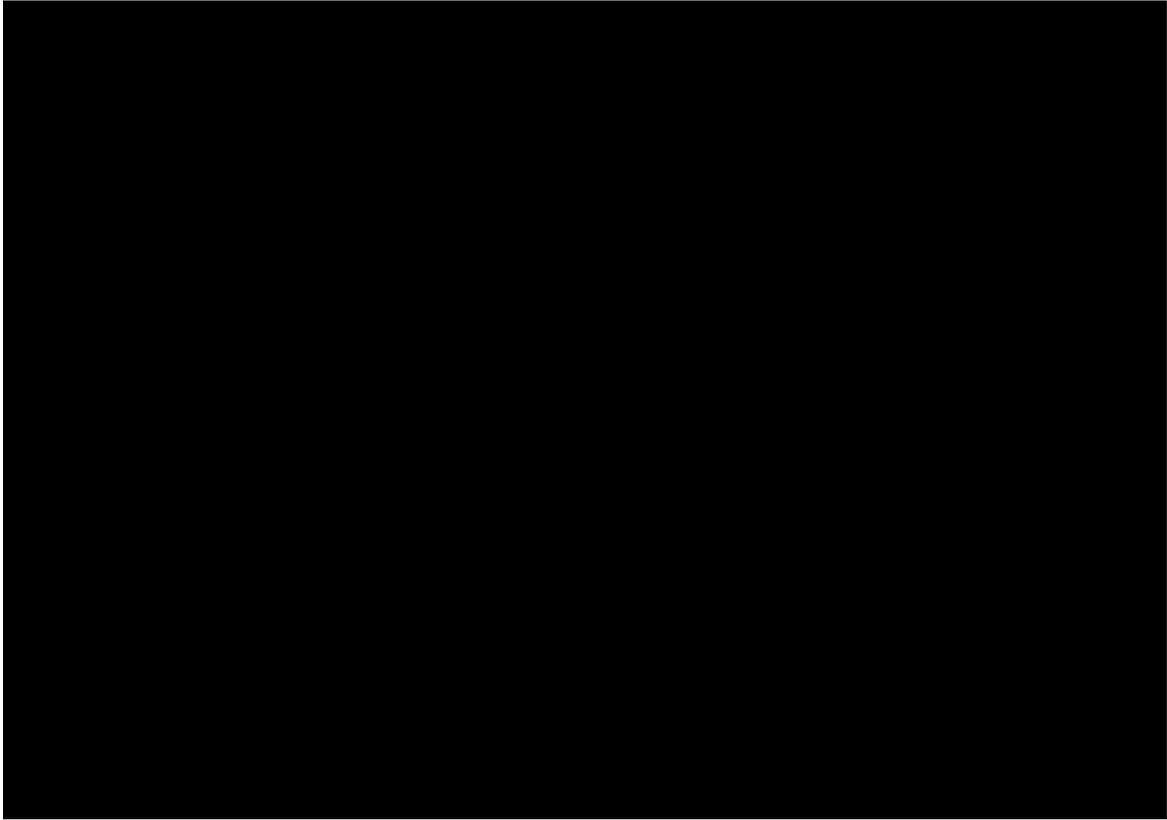








49\_182245\_01 - Overhead Line Design - 110kV Eden to Castlereagh  
Line Refurbishment Buildability Report





## Appendix 4: Eden – Carnmoney

### Tower Access Drawing Numbers

LSTC Drawing Index No. 22\_182245\_160

Tower Number	LSTC Drawing No.
59	55_182245_108
59A	55_182245_109
60	55_182245_110
61	55_182245_111
62	55_182245_112
63	55_182245_113
64	55_182245_114
65	55_182245_115
65A	55_182245_116
66	55_182245_117
67	55_182245_118
68	55_182245_119
69	55_182245_120
70	55_182245_121
71	55_182245_122
72	55_182245_123
73	55_182245_124
74	55_182245_125
75	55_182245_126
76	55_182245_127
77	55_182245_128
78	55_182245_129
79	55_182245_130
80	55_182245_131
81	55_182245_132
82	55_182245_133

Tower Number	LSTC Drawing No.
83	55_182245_134
84	55_182245_135
85	55_182245_136
86	55_182245_137
87	55_182245_138
88	55_182245_139
89	55_182245_140
90	55_182245_141
91	55_182245_142
92	55_182245_143
93	55_182245_144
94	55_182245_145
95	55_182245_146
96	55_182245_147
97	55_182245_148
98	55_182245_149
99	55_182245_150
100	55_182245_151
101	55_182245_152
102	55_182245_153
103	55_182245_154
104	55_182245_155
105	55_182245_156
106	55_182245_157
106A	55_182245_158

XX	Tension tower
YY	Replacement tower



## Appendix 5: Carnmoney – Finaghy

### Tower Access Drawing Numbers

LSTC Drawing Index No. 22\_182245\_159

Tower Number	LSTC Drawing No.
106B	55_182245_47
107	55_182245_48
107A	55_182245_49
108A	55_182245_50
108	55_182245_51
109	55_182245_52
110	55_182245_53
110A	55_182245_54
111	55_182245_55
112	55_182245_56
113	55_182245_57
113A	55_182245_58
114	55_182245_59
115	55_182245_60
116	55_182245_61
117	55_182245_62
118	55_182245_63
119	55_182245_64
120	55_182245_65
121	55_182245_66
122	55_182245_67
123	55_182245_68
124	55_182245_69
125	55_182245_70
126	55_182245_71
127	55_182245_72
128	55_182245_73
129	55_182245_74
130	55_182245_75
131	55_182245_76
132	55_182245_77

Tower Number	LSTC Drawing No.
133	55_182245_78
134	55_182245_79
135	55_182245_80
136	55_182245_81
137	55_182245_82
138	55_182245_83
139	55_182245_84
140	55_182245_85
141	55_182245_86
142	55_182245_87
143	55_182245_88
144	55_182245_89
145	55_182245_90
146	55_182245_91
147	55_182245_92
148	55_182245_93
149	55_182245_94
150	55_182245_95
151	55_182245_96
152	55_182245_97
153	55_182245_98
154	55_182245_99
155	55_182245_100
156	55_182245_101
157	55_182245_102
158	55_182245_103
159	55_182245_104
160	55_182245_105
160A	55_182245_106
161	55_182245_107

XX	Tension tower
----	---------------



## Appendix 6: Finaghy – Castlereagh

### Tower Access Drawing Numbers

Drawing Index No. 22\_182245\_159

Tower Number	LSTC Tower Access Drawing No.
1	55_182245_05
2	55_182245_06
3	55_182245_07
4	55_182245_08
5	55_182245_09
6	55_182245_10
7	55_182245_11
8	55_182245_12
9	55_182245_13
10	55_182245_14
11	55_182245_15
11A	55_182245_16
12	55_182245_17
13	55_182245_18
14	55_182245_19
15	55_182245_20
16	55_182245_21
17	55_182245_22
18	55_182245_23
19	55_182245_24
20	55_182245_25

Tower Number	LSTC Tower Access Drawing No.
21	55_182245_26
22	55_182245_27
23	55_182245_28
24	55_182245_29
25	55_182245_30
26	55_182245_31
27	55_182245_32
28	55_182245_33
29	55_182245_34
30	55_182245_35
31	55_182245_36
32	55_182245_37
33	55_182245_38
33A	55_182245_39
34	55_182245_40
35	55_182245_41
36	55_182245_42
37	55_182245_43
37A	55_182245_44
37B	55_182245_45
38	55_182245_46

XX	Tension tower
----	---------------



## **Appendix 7: SONI**

### **Castlereagh – Eden Scope of Work**





## **Appendix 8: Norpower Overhead Line Services**

### **Budgetary Prices Report**

