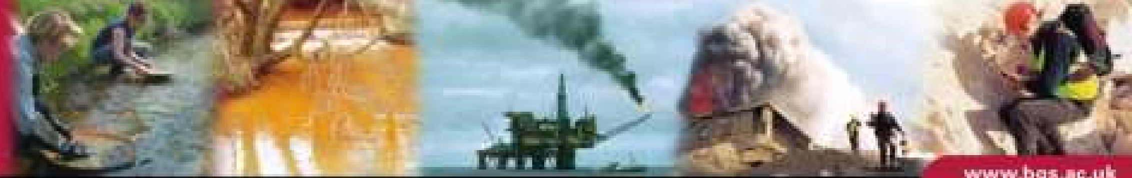
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL



www.bgs.ac.uk

# Quarry Fines Minimisation

**Clive Mitchell**
Industrial Mineral Specialist

Kingsley Dunham Centre
Keyworth
Nottingham NG12 5GG
Tel 0115 936 3100



NATURAL
ENVIRONMENT
RESEARCH COUNCIL

# Outline of Presentation

- What are Quarry Fines?
- Why Minimisation?
- Statistics
- What Industry Thinks
- Good Practice for Low Fines
- Case Study
- Conclusions

# What are Quarry Fines ?

- **BS EN Fine aggregate** - <4mm (<2mm for asphalt)
- **BS EN Fines** - inherent material <0.063mm

  (<63 microns, equivalent to width of human hair)
- **BS EN Filler** - material <0.063mm added to products
- **'Quarry fines'** (also known as 'dust' or 'fines')

  Material finer than 4mm (or 3.35 / 3 / 5mm)
- As distinct from nuisance dust (which forms part of it)


**Quarry fines stockpile, Gritstone Quarry**

# How are Fines Formed?

- **Extraction** - drilling & blasting, haulage/ transfer
- **Primary crushing** - scalping pre- or post-crushing, primary surge pile
- **Secondary crushing (& further stages)** – cone & impact
- **Screening** - production of aggregate products inc. quarry fines, recirculation/ recrushing of oversize & coarse aggregate
- **Stockpiling** - uncovered or covered
- **Handling/ distribution/ transportation**
- **Fines/ dust management**



# How are fines formed: 2

- Fines a function of crushing, mineralogy, texture, breakage characteristics & size distribution
- Fine grained and flaky material tends to produce more fines than coarse grained and blocky material
- **Limestone** - inherently softer, typically 20 - 25% fines
- **Gritstone** - demand cubical high-PSV, 35 - 40% fines
- **Igneous & metamorphic** - wide range, typically hard & durable, 10 - 30% fines


# Quarry fines produced at each stage

| Production Stage | Quarry fines produced by hard rock quarries | |
|---|---|---|
| Primary crusher | Igneous | 3 – 6% (Jaw) to 10-15% (Gyratory) |
| | Limestone | 6 – 7% (Jaw) to 20% (Impact) |
| | Gritstone | 1 – 2% (Jaw) to 15 – 20% (Jaw & Gyratory) |
| Secondary crusher | Igneous | 10 – 23% (Cone) |
| | Limestone | <10% (Cone) to <20% (Impact) |
| | Gritstone | 4 – 5% (Jaw & Cone) |
| Tertiary crusher (& further) | Igneous | 5 – 30% (Cone) to 40% (Impact) |
| | Limestone | < 20% (Impact) to 40% (Hammer mill) |
| | Gritstone | ~15% (Cone) to 40% (Impact) |

**Primary crusher (Gyratory), Granite Quarry**

Scalpings stockpile, Gritstone Quarry

**Primary surgepile, Limestone Quarry**

**Quarry fines stockpile, Limestone quarry**

# Why minimisation ?

- **Changes in market:** Increasing stocks
- **Aggregate Levy:** Discouraged use of quarry fines in favour of cheaper alternatives
- **Market trends:** Thin (re)surfacing of roads & demand for finer aggregate (14 & 10mm) means increased fines production
- **Quarry fines utilisation:** Often involves finding new markets, mostly used in asphalt & concrete products
- **Minimising fines production:** Prevention rather than cure, optimising resource use


**Crushed gravel, Sand & Gravel quarry**


# Statistics

**<u>Defra statistics</u>** mineral waste : saleable product ratio 1 : 9

www.defra.gov.uk/environment/statistics/waste/wrmineral.htm


## BGS estimates of quarry fines

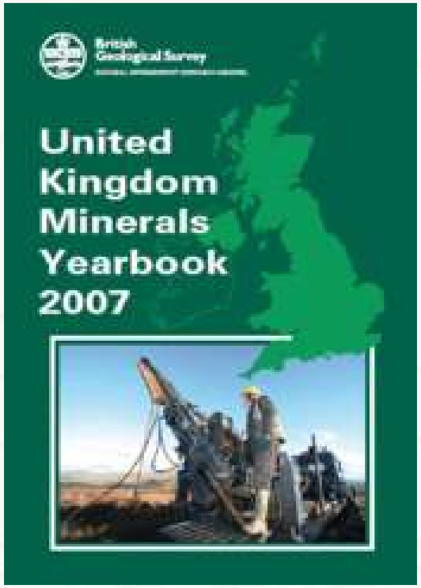
1 : 9 for Sand & Gravel (<0.063mm)

1 : 4 for Limestone and Igneous & Metamorphic

1 : 3 for Sandstone

**UK Minerals Yearbook 2007 * free download ***

www.mineralsuk.com/britmin/ukmy2007.pdf




# Production, Waste & Fines

| Rock Type | **Production** (Mtpa, 2007e) | **Mineral Waste** [1] (Mtpa, 2007e) | **Quarry Fines** [2] (Mtpa, 2007e) |
|---|---|---|---|
| **Limestone** | **95.0** | **10.6** | **23.8** |
| **Igneous + Metamorphic** | **57.0** | **6.3** | **14.3** |
| **Sandstone** | **19.0** | **2.1** | **6.3** |
| **Sand + Gravel** | **93.0** | **10.3** | **10.3** |
| **Total** | **264.0** | 28.4 | 52.6 |

**1** = Defra : Waste : Product ratio of 1 : 9 ; **2** = UKMY: Fines : Product ratio 1 : 9 for Sand + Gravel (<0.063mm), 1 : 4 for Limestone, Igneous + Metamorphic and 1 : 3 for Sandstone; **2007e** = estimated production

**Quarry fines stockpile, Gritstone Quarry**

**Natural dust suppression, Gritstone Quarry**



# What the industry think

- Quarry fines production & stockpiling usually known
- How much at each production stage usually a guess
- More focus on ‘nuisance’ dust control
- Many produce too much (~65%), some have a balance (~25%) & a few can’t meet demand (~10%)
- Minimisation a secondary consideration
- Process audits & optimisation reviews are apparently rare
- Rely on equipment manufacturer advice

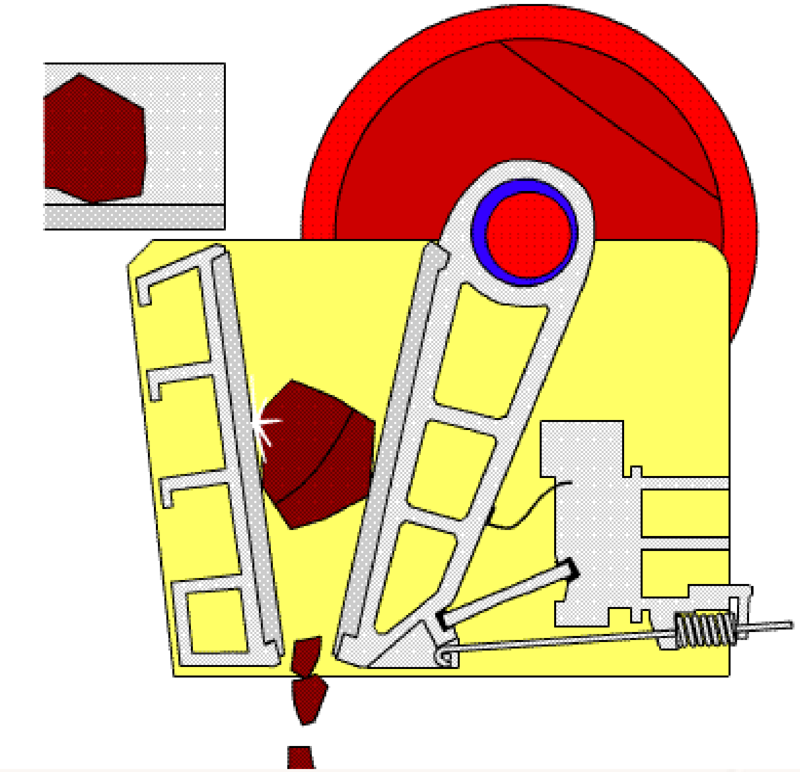
**Working benches, Gritstone Quarry**

**Covered dust stocks, Gritstone Quarry**



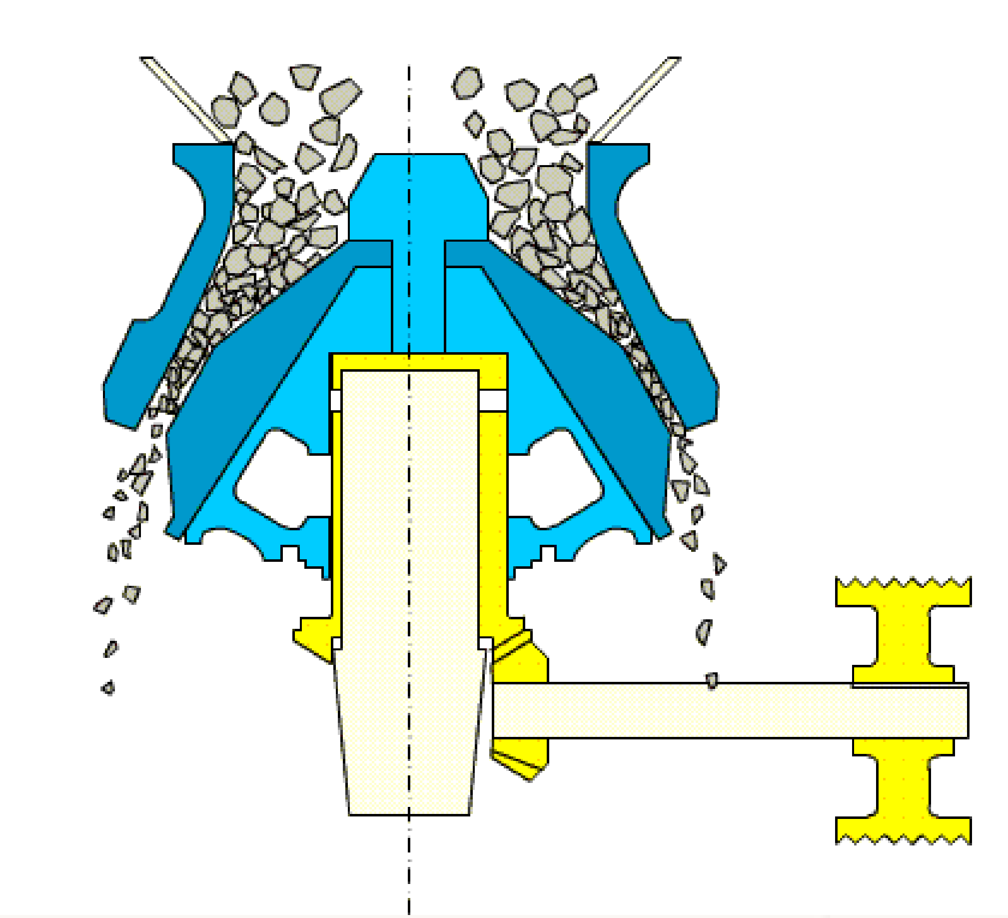
# Good Practice for Low Fines

- Modern crusher technology with the correct process
- Size reduction ratio less than 6:1
- Choke feeding of jaw & cone crushers will minimise top size of product
- Lower crusher speed will lead to lower fines generation
- Evenly distributed feed to cone & impact crushers
- Screening between crushing stages
- Open circuit crushing
- Proper training of operators



**Jaw Crusher**

http://www.aggdesigns.com/Jaw-Crusher-info.htm



**Cone Crusher**

http://www.aggdesigns.com/Cone-Crusher-info.htm

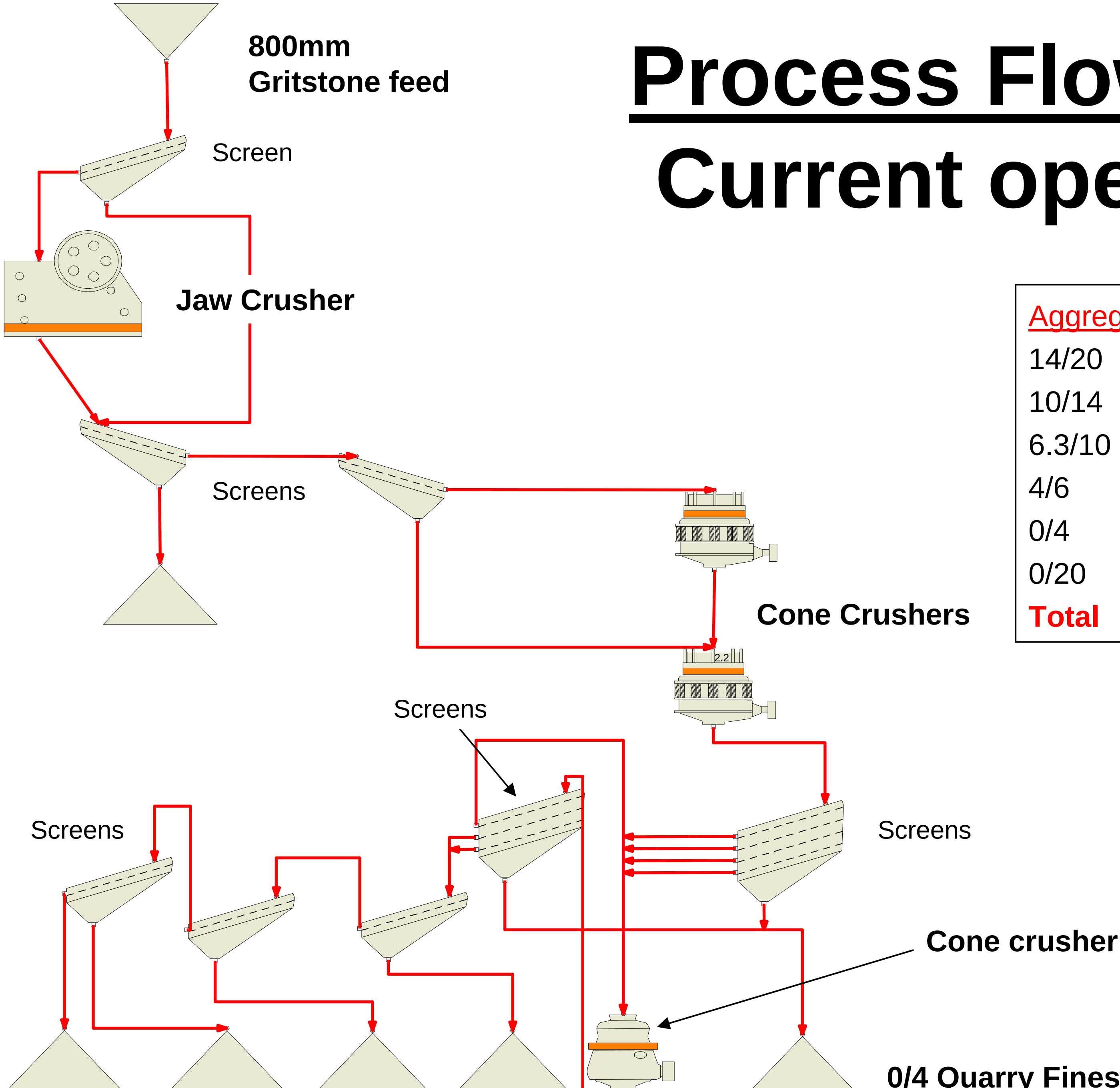

# Case Study: Gritstone Quarry

- **Operation**: Gritstone quarry in SW England
- **Market** : High PSV roadstone aggregate, 10mm mainly
- **Production**: Four-stage crushing, Jaw + Cone Crushers, aim for cubical aggregate, 38% fines
- **Process optimisation**: Process audit to determine ‘mass balance’
- **Simulation**: Three stage crushing inc. VSI, particle shape maintained with 27% fines (potential increase in filler fines a concern)
- **Alternative**: Screening aggregate after tertiary stage

# Process Flowsheet

# Current operation

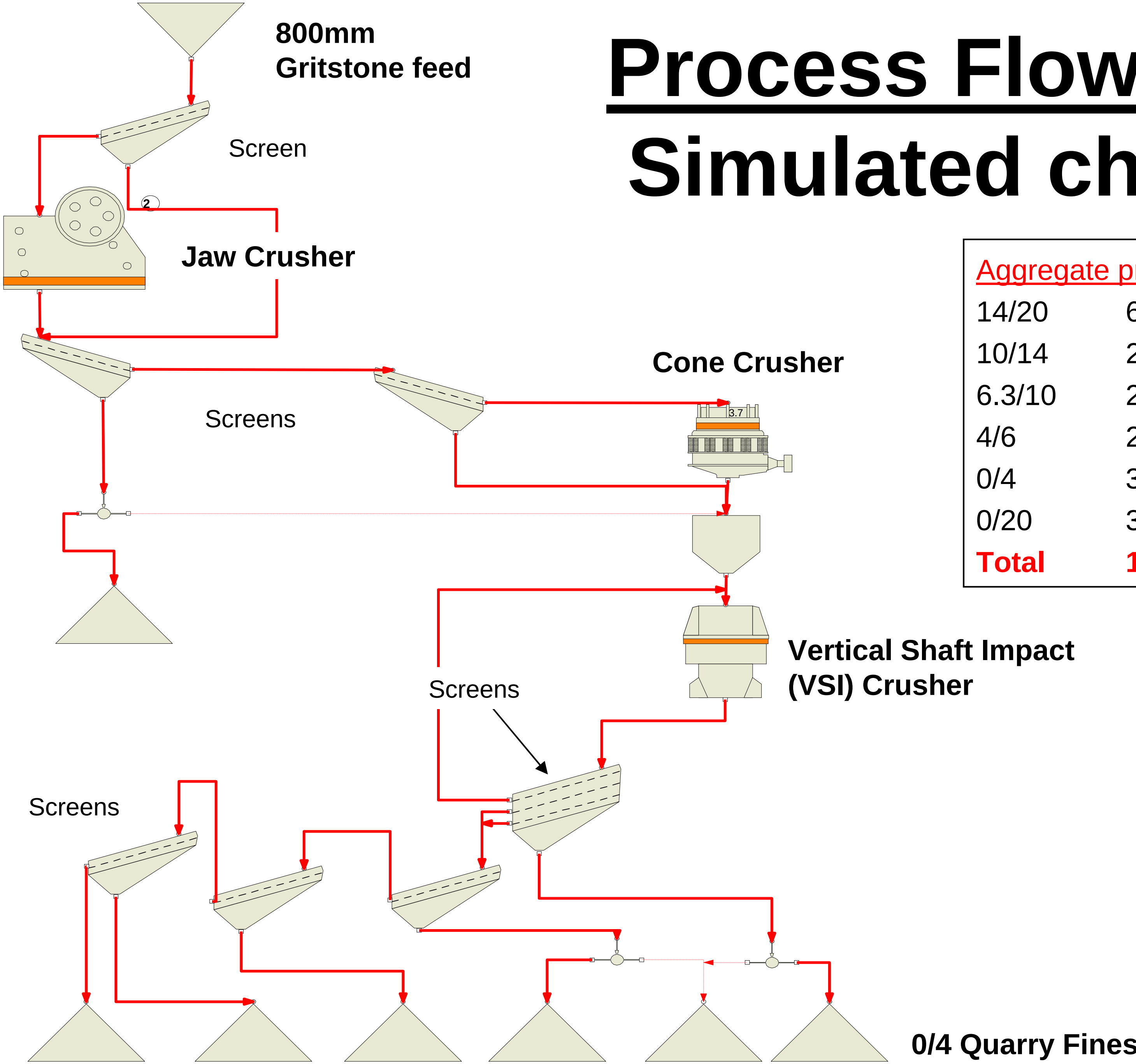
| Aggregate products | | |
|---|---|---|
| 14/20 | 5 tph | **4%** |
| 10/14 | 15 tph | **10%** |
| 6.3/10 | 21 tph | **14%** |
| 4/6 | 18 tph | **12%** |
| 0/4 | 55 tph | **38%** |
| 0/20 | 32 tph | **22%** |
| **Total** | **145 tph** | **100%** |



# Process Flowsheet

# Simulated change

| Aggregate products | | |
|---|---|---|
| 14/20 | 6 tph | **4%** |
| 10/14 | 24 tph | **17%** |
| 6.3/10 | 24 tph | **17%** |
| 4/6 | 20 tph | **14%** |
| 0/4 | 39 tph | **27%** |
| 0/20 | 32 tph | **22%** |
| **Total** | **145 tph** | **100%** |



# Gritstone quarry case study

| Product<br>Min / max, mm | Current operation<br>yield | Simulated change<br>yield |
|---|---|---|
| 14 / 20 | **4%** | **4%** |
| 10 / 14 | **10%** | **16.5%** |
| 6.3 / 10 | **14%** | **16.5%** |
| 4 / 6 | **12%** | **14%** |
| 0 / 4 | **38%** | **27%** |

36 % Vs 47%

11% reduction in fines equals 11% increase in aggregate production

# Business Case

- **Energy input** into aggregate crushing
- Every kilowatt hour (kWh) electricity costs 6.17pence (BERR 2008 Q2) with 0.523kg $CO_2$ emission (Defra)
- **For each 10% reduction** in fines there is 2 to 3% decrease in energy costs (& $CO_2$ emission)
- Quarry fines minimisation of 25 - 40% is realistic
- **Reduction** in crushing cost & $CO_2$ emission of greater than 10% would be possible

# Conclusions

- **Quarry fines are a problem**
  In 2/3 of quarries, stockpiles are growing
- **Performance assessments are needed**
  Process audits can highlight production changes
- **More efficient resource use**
  Minimisation = optimisation of resource use
- **Bottom line**
  Reduced fines = lower cost + lower $CO_2$ emission

# Thank you for listening

Contact details

Clive Mitchell

British Geological Survey

Keyworth, Nottingham, NG12 5GG

Tel. +44(0)115 936 3257

Fax. +44(0)115 936 3520

Email: cjmi@bgs.ac.uk

Web: www.bgs.ac.uk/mineralsuk